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E.1.

PRESSURES ON THE TEETH OF SKEW GEARS.

By V. LEHEL.

(*Concluded from page 222.*)

IT was shown by Herz,* that, if two ellipsoids are in contact, and their major axes enclose the angle δ, the figure of contact is of elliptical shape, and the half of the major axis a and of the minor axis b are defined by :

$$a = \mu \sqrt[3]{\frac{3}{8} \frac{P(\delta_1 + \delta_2)}{\sigma_1 + \sigma_2 + \sigma_3 + \sigma_4}} \quad . \quad (8)$$

$$b = \nu \sqrt[3]{\frac{3}{8} \frac{P(\delta_1 + \delta_2)}{\sigma_1 + \sigma_2 + \sigma_3 + \sigma_4}} \quad . \quad (9)$$

where P is the load under which the two surfaces contact, σ_1, σ_2, σ_3, σ_4, are the measures of curvature in the two principal sections of the surfaces in the point of tangency (σ_1 and σ_2 referring to one, σ_3 and σ_4 to the other surface), δ_1 and δ_2 are the Kirchoff's modules of elasticity, which are directly proportional to the modulus of elasticity as generally used in mechanics. μ and ν are functions of an auxiliary angle τ, the relation between which are defined by the formulæ† :

$$\nu = \sqrt[3]{\frac{2}{\pi} E \cos \epsilon}; \quad \mu = \frac{\nu}{\cos \epsilon}$$

$$\sin^2 \frac{\tau}{2} = \cot^2 \epsilon \frac{K - E}{E}$$

where K and E are the total elliptical integrals of first and second order relating to the module $\sin \epsilon$.

The relations of angle τ to the two contacting surfaces may be gained from the following equations, also derived by Herz :

$$\cos \tau = -\frac{A - B}{A + B}$$

where

$$2(A - B) = -$$

$$\sqrt{(\sigma_1 - \sigma_2)^2 + 2(\sigma_1 - \sigma_2) \times (\sigma_3 - \sigma_4) \cos 2\delta + (\sigma_3 - \sigma_4)^2}\ddagger$$

and

$$2(A + B) = \sigma_1 + \sigma_2 + \sigma_3 + \sigma_4.$$

δ, as before, denotes the angle enclosed by the main axes of the two contacting surfaces.

If both of the contacting surfaces are cylinders,

$$\sigma_2 = 0 \text{ and } \sigma_4 = 0,$$

and the substitution :

$$\frac{\sigma_1}{\sigma_3} = \frac{r_2}{r_1} = K$$

being made, the formula will be in a simplified form :

$$\cos \tau = \frac{1}{K + 1} \sqrt{K\left(K + 2 \cos 2\delta + \frac{1}{K}\right)} \quad (10)$$

As it was seen from (7), the minimum radii of curvature for the two surfaces are :

$$r_1 = R_1 \frac{\sin^2 \phi_1}{\sin \phi} \text{ and, similarly, } r_2 = R_2 \frac{\sin^2 \phi_2}{\sin \phi}.$$

Introducing these expressions and bearing in mind the relationships,

$$R_1 = \frac{Z_1 \cdot m}{2 \cdot \cos \beta_1}, \quad . \quad . \quad . \quad (11)$$

and

$$R_2 = \frac{Z_2 \cdot m}{2 \cos \beta_2} \cdot \quad . \quad . \quad . \quad (12)$$

$$K = \frac{Z_2 \cos \beta_1 \sin^2 \phi_2}{Z_1 \cos \beta_2 \sin^2 \phi_1} \quad . \quad . \quad (13)$$

where β_1 and β_2 are the helix angles, Z_1 and Z_2 the number of teeth, m the module of the forming rack at right angles to the direction of the teeth of the rack, and where the suffixes 1 should refer to the driving, and 2 to the driven gear.

If the axes of the two gears are at right angles to one another,

$$\beta_2 = 90 \text{ deg.} - \beta_1,$$

and

$$K = \frac{Z_2}{Z_1} \cot \beta_1 \frac{\sin^2 \phi_2}{\sin^2 \phi_1} \quad . \quad . \quad (14)$$

It was shown by Herz that if the pressure were represented by vectors perpendicular to the surface of contact, the end points of these vectors would form the half of an ellipsoid. The maximum pressure thus acts in the middle, while pressure at the periphery of the ellipse of contact falls to zero. If the total load under which contact occurs be P, the maximum pressure inside the ellipse of the semi-axes a and b will be

$$\Theta_{max.} = \frac{3}{2} \frac{P}{a.\, b.\, \pi} \quad . \quad . \quad (15)$$

Making the substitutions :

$$\delta_1 = \frac{3 \cdot 56}{E_1} \text{ and } \delta_2 = \frac{3 \cdot 56}{E_2}$$

and $$\sigma_2 = \sigma_4 = 0\ ;\ \sigma_1 = \frac{1}{r_1} \text{ and } \sigma_3 = \frac{1}{r_2},$$

$$a = \mu\ 1 \cdot 1 \sqrt[3]{P \frac{E_1 + E_2}{E_1 E_2} \frac{r_1 r_2}{r_1 + r_2}} \quad (16)$$

$$b = \nu\ 1 \cdot 1 \sqrt[3]{P \frac{E_1 + E_2}{E_1 E_2} \frac{r_1 r_2}{r_1 + r_2}} \quad (17)$$

The maximum of surface pressure may be given from 15, 16, and 17, as :

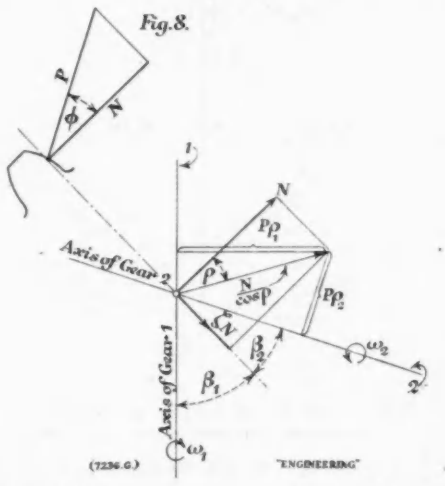
$$\Theta_{max.} = \frac{0 \cdot 394}{\mu \nu} \sqrt[3]{P \left(\frac{E_1 E_2}{E_1 + E_2}\right)^2 \times \left(\frac{r_1 + r_2}{r_1 r_2}\right)^2} \quad . \quad . \quad (18)$$

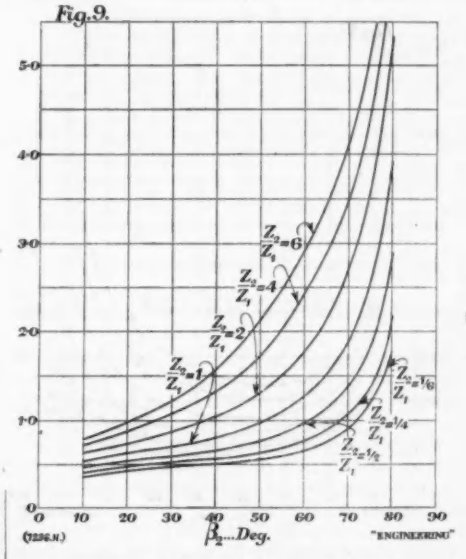
Adapting this formula to actual skew gears, it should be remembered that P denotes the force acting perpendicularly to the common tangent plane at the point of contact, and also that considerable slip along the teeth takes place during the rotation of the gears, which slip will result in friction. In the following, only the friction along the length of the teeth will be considered, the friction in the plane of rotation, being comparatively small, being neglected. The relation between peripheral force and contact pressure may be seen from Fig. 8. N is the projection of P into the tangent plane of the two pitch cylinders, and at right angles to the direction of the teeth

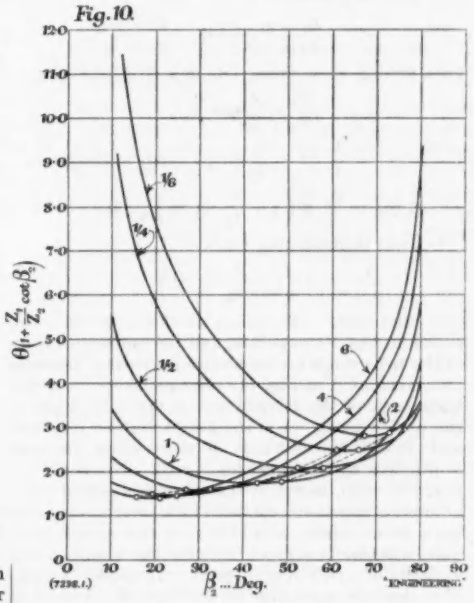
$$N = P \cos \phi$$

Due to slip along the teeth, a frictional force ξN will arise in the direction of the teeth, if ζ is the coefficient of friction. The peripheral forces $P\rho_1$ and $P\rho_2$ will have to balance with the resultant of N and ξN. The angle of friction may be obtained from $\rho = \tan \xi$, and the resultant will be

$$\frac{N}{\cos \rho}.$$







If, in Fig. 8, the gear turning about the axis 1 be the driver

$$N = \frac{P \rho_2}{\cos(\beta_2 + \rho)} \cos \rho,$$

where $P\rho_2$ is the peripheral force on the gear 2. The pressure P perpendicular to the surface will be :

$$P = \frac{P \rho_2}{\cos(\beta_2 + \rho)} \frac{\cos \rho}{\cos \phi}.$$

Substituting this expression for P in (18), the maximum unit surface pressure will be :

$$\Theta_{max.} = \frac{0 \cdot 394}{\mu \nu} \sqrt[3]{\frac{P \rho_2 \cos \rho}{\cos \omega \cos(\beta_2 + \rho)} \left(\frac{E_1 E_2}{E_1 + E_2}\right)^2 \left(\frac{r_1 + r_2}{r_1 r_2}\right)^2}$$

Substituting $\tan \rho = \zeta = 0 \cdot 1$, *i.e.*, $\rho = 5$ deg. 45 min., and $\phi = 15$ deg., and introducing the expression

$$\left(\frac{E_1 E_2}{E_1 + E_2}\right)^{\frac{2}{3}} = e_m,$$

depending on the properties of the material only,

$$\Theta_{max.} = \frac{0 \cdot 394}{\mu \nu} e_m \sqrt[3]{\frac{P \rho_2}{\cos(\beta_2 + \rho)} \left(\frac{r_1 + r_2}{r_1 r_2}\right)^2}$$

Making the further substitution $\frac{r_2}{r_1} = K$, and assuming the most usual case, when $\beta_1 + \beta_2 = 90$ deg., and

$$K = \frac{Z_2}{Z_1} \cot \beta_1 \frac{\sin^2 \phi_2}{\sin^2 \phi_1} \cdot \quad . \text{ (see 14)}$$

$$\Theta_{max.} = e_m \sqrt[3]{\frac{P \rho_2}{R_2}} \times \frac{0 \cdot 162}{\mu \nu} \sqrt[3]{\frac{(1 + K)^2}{\sin^4 \phi_2 \times \cos(\beta_2 + \rho)}}$$

---

* See H. Herz, "Über die Härte" and "Über die Berührung fester elastischer Körper," in *Gesammelte Werke*, Leipzig, 1895.

† See Dr. A. Palmgren, *Die statische Tragfähigkeit von Kugellagern*, Göteborg.

‡ In Herz's original paper the symbol ω was used for δ. Considering that in engineering practice ω is generally used to denote angular velocity, it has been thought advisable to substitute another symbol to avoid confusion.

The value

$$\frac{0{\cdot}162}{\mu\ \nu}\sqrt[3]{\frac{(1+K)^2}{\sin^6\phi_2\times\cos(\beta_2+\rho)}}=\theta$$

may be expressed as a function of the helix angles β_1 or β_2, and of the gear ratio $\frac{Z_2}{Z_1}$, and may be represented in a diagram (see Fig. 9), page 241, by a group of curves. With the substitution of θ, the unit pressure will be :

$$\Theta_{max.}=e_m.\ \theta\sqrt[3]{\frac{P\ \rho_2}{R_2}},$$

or, introducing the torque $M_2=P\rho_2\times R_2$,

$$\Theta_{max}=\frac{e_m\times\theta}{R_2}\sqrt[3]{M_2}\ .\qquad .\qquad (19)$$

It may be of interest to find the helix angle β_2 which, at a given centre distance and at a given torque load M_2 on the driven gear, will give the lowest surface pressure.

If the distance between the centres be T, $T=R_1+R_2$, where

$$R_1=\frac{Z_1\times m}{2\cos\beta_1},\text{ and }R_2=\frac{Z_2\times m}{2\cos\beta_2}$$

for a 90-deg. skew drive, *i.e.*, if $\beta_1+\beta_2=90$ deg.

$$\frac{R_1}{R_2}=\frac{Z_1}{Z_2}\cot\beta_2$$

$$\frac{1}{R_2}=\frac{1}{T}\left(1+\frac{Z_1}{Z_2}\cot\beta_2\right)\text{ and, with (19),}$$

$$\Theta_m=\frac{e_m}{T}\ \theta\left(1+\frac{Z_1}{Z_2}\cot\beta_2\right)\sqrt[3]{M_2}$$

Θ_m will be minimum, when

$$\theta\left(1+\frac{Z_1}{Z_2}\cot\beta_2\right)$$

is a minimum. The values of this expression are shown in Fig. 10, page 241, and the optimum values of the helix angle giving the lowest surface pressure are shown at A in Fig. 11. In this figure, β_1 is the helix angle of the driving, and β_2 the helix angle of the driven gear. A is the lowest surface pressure, and B the lowest value of the surface pressure multiplied by the rubbing speed. It should be borne in mind, however, that there is a considerable amount of slip at the contact of the teeth of engaging skew gears, which, in addition to the surface pressure, will also be a factor defining the load-carrying capacity of a pair of skew gears. It appears reasonable that, as in the case of bearings, the product of unit surface pressure and rubbing speed should be chosen as a basis for comparison. This will, to a greater or lesser extent, also bear a relation to the temperature at the contact and thus may supply a clue to the possibility of scoring of the tooth surfaces.

In dealing with the rubbing speed, it will again be the rubbing speed along the length of the teeth that will be considered, and in the plane of rotation it will be neglected.

The rubbing speed, V_c, will be* (see Fig. 12), $V_c=R_1.\omega_1\sin\beta_1+R_2\omega_2\sin\beta_2$; substituting (11) and (12), and also

$$\frac{Z_1}{Z_2}=\frac{2}{1}$$

and assuming that $\beta_1+\beta_2=90$ deg.,

$$V_c=R_2\ \omega_2\ (\sin\beta_2+\cos\beta_2\cot\beta_2)$$

and

$$\Theta_{max}.\ V_c=e_m.\ \omega_2\sqrt[3]{M_2.\ \theta\ (\sin\beta_2+\cos\beta_2\cot\beta_2)}.$$

Conditions will be most favourable for a helix angle β_2 of the driven gear when $\theta(\sin\beta_2+\cos\beta_2\cot\beta_2)$ is a minimum.

The values of this expression are shown in the diagram, Fig. 13, for various gear ratios, and B in Fig. 11 shows the optimum helix angles. It is interesting that the value of $\Theta_m.\ V_c$ does not depend on the dimensions of the gear, since it will be seen that the radius of the gear does not appear in the equation. This will be clear if it is considered that Θ_m is inversely proportional to the radius of the gear and V_c increases proportionally with the radius, whereby the effect of the radius will be eliminated.

In order to compare the permissible surface pressures with those in ordinary spur gears, a series of tests was carried out on a pair of skew gears

* See A. Schlebel, *Zahnräder*.

CONTACT PRESSURES ON SKEW-GEAR TEETH.

Fig. 11.

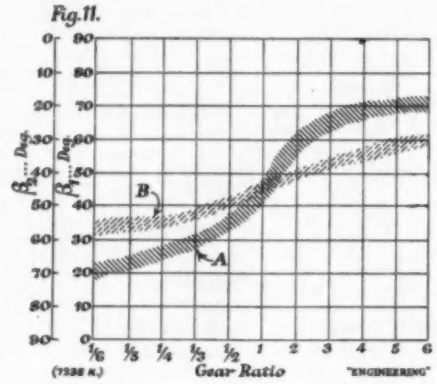
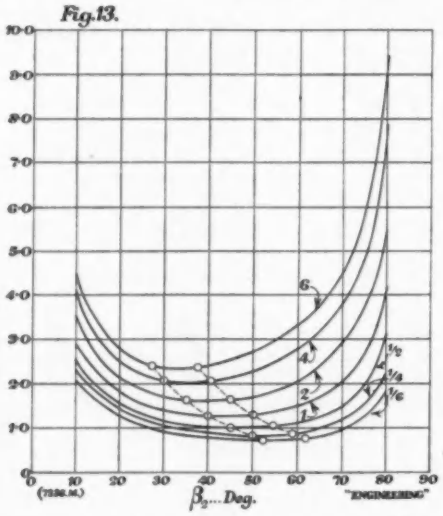


Fig. 13.



at the works of Messrs. Ganz and Company, Budapest. The dimensions of the gears were as follows :—

	Driver.	Driven.
Number of teeth ...	19	38
Helix angle	61 deg. 30 min.	28 deg. 30 min.
Pitch circle	258·8 mm.	281·1 mm.
Outside diameter ...	271·8 mm.	294·1 mm.
Module of cutting tool...	6·5 mm.	
Pressure angle of tool ...	15 deg.	

The gears were made of cast iron with a Brinell hardness of 217, and were cut on a hobbing machine. The smaller gear was driven by an electric motor at the speed of 300 r.p.m., the other one being loaded by a Prony brake. The gears were arranged in an enclosed sheet-metal housing, the smaller one being uppermost and the lower dipping into oil about 1½ in. deep. Commercial quality of Vacuum Mobiloil BB was used for lubrication, and the tests were carried out with an oil temperature of about 40 deg. to 45 deg. C. It was found that the temperature of the oil became constant at a certain fixed temperature as long as the load could be carried by the gears without damage to the contacting surfaces, but as soon as the load was sufficient to start scoring of the teeth, the temperature showed a steady rise without any tendency to become constant. It appeared that a very useful method of indicating the commencement of scoring of the tooth flanks would be obtained keeping a constant watch on the temperature of the oil. It was found that if the gears were stopped in a comparatively short time when a steady rise of the temperature was experienced, no serious damage was caused to the gears, but otherwise serious scoring of the teeth inevitably resulted. The maximum torque that could be carried in the circumstances described, as obtained from a number of tests, was always about $M_2=2{,}035$ cm.-kg., measured on the shaft of the driven gear.

The surface pressure could be calculated from the formula

$$\Theta_m=e_m\times\frac{\theta}{R_2}\sqrt[3]{M_2}.$$

Fig. 12.

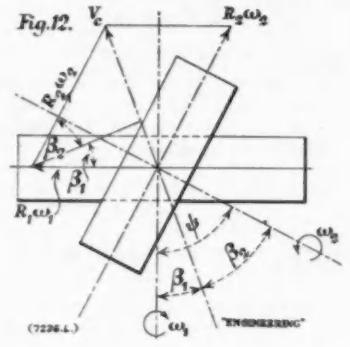
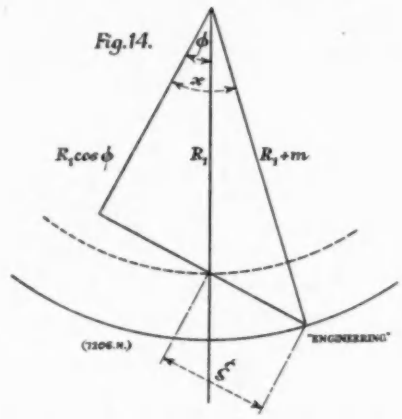


Fig. 14.



With a modulus of elasticity of 850,000 kg. per square centimetre for both gears, $e_m=5{,}680$. At $\frac{Z_2}{Z_1}=2$ and $\beta_2=28$ deg. 30 min., $\theta=0{\cdot}85$ (see Fig. 9, page 241.) Inserting these values,

$$\Theta_m=435\text{ kg. per square centimetre.}$$

In normal spur gears, it is considered safe to allow about $\Theta_{max.}=6{,}300$ kg. per square centimetre.* The difference between the two figures may be accounted for by the greater slip on the teeth of the skew gear. It should be realised that the figure 435 kg. per square centimetre obtained is a maximum load, and the safe load may be taken at perhaps as low as one-half of this. The product of surface pressure and rubbing speed calculated similarly from the preceding formulæ, will be found to be

$$\Theta_m\times V_c=1980\ \frac{\text{kg.}}{\text{cm.}^2}\ \frac{\text{m.}}{\text{sec.}}$$

which figure might serve as a basis for actual designs —making the necessary allowance for a factor of safety.

It is remarkable that skew gears may be regarded as a reliable means of transmitting reasonably high powers if the angle between their axes is not very great.* An example will best demonstrate the possibilities in this direction. Let it be assumed that the angle of the two axes is 12 deg., as projected to a plane perpendicular to the common normal of the two axes. Let the number of teeth be $Z_1=Z_2=40$, and for the sake of simplicity, let an equal helix angle for both gears be assumed. $\beta_1=\beta_2=6$ deg., assuming a tool of 0·6 cm. module, and 15 deg. pressure angle. The angle between the straight contact lines of the contacting teeth $\delta=\alpha'+\alpha''$, may be calculated from equation (2), page 222, *ante*,

$$\tan\alpha'=\sin\phi.\tan\beta_1,\text{ and }\delta'=\alpha'',$$

whence

$$\delta=3\text{ deg. }7\text{ min.}$$

The half axes of the ellipse of contact will be :—

$$a=\mu\ 1{\cdot}1\sqrt[3]{P\ \frac{E_1+E_2}{E_1E_2}\cdot\frac{r_1r_2}{r_1+r_2}}\qquad\text{see (16)}$$

$$b=\nu\ 1{\cdot}1\sqrt[3]{P\ \frac{E_1+E_2}{E_1E_2}\cdot\frac{r_1r_2}{r_1+r_2}}\qquad\text{see (17)}$$

* See Dr. Georg Schlesinger, "Modern Methods of Spur Gear Calculation," ENGINEERING, vol. 142, page 457 (1936).

$$\cos\tau = \frac{1}{K+1}\sqrt{K\left(K + 2\cos 2\delta + \frac{1}{K}\right)} \text{ see (10)}$$

$$K = \frac{r_2}{r_1} = 1$$

and

$$\cos\tau = \frac{1}{2}\sqrt{2 + 2\cos 6 \text{ deg. } 14 \text{ min.}} = 0{\cdot}99852.$$

and with (7) and (11)

$$r_1 = r_2 \frac{Z_1 . m.}{2\cos\beta_1} \frac{\sin^2\phi_1}{\sin\phi}$$

$$= \frac{40 . 0{\cdot}6 \text{ cm.}}{2\cos 6 \text{ deg.}} \times \frac{\sin^2 15^\circ\ 4'\ 40''}{\sin 15 \text{ deg.}} = 3{,}155 \text{ cm.}$$

Assuming case-hardened chrome-nickel steel, E = 2,200,000 kg. per square centimetre,

$$1{\cdot}1\sqrt[3]{\frac{E_1 + E_2}{E_1 E_2} \times \frac{r_1 r_2}{r_1 + r_2}} = 1{\cdot}237 \times 10^{-2}$$

since

$\cos\tau = 0{\cdot}99852$ (interpolated from Table I); $\mu = 16{\cdot}043$; $\nu = 0{\cdot}1994$;

TABLE I. *Values of μ and ν.**

Cos τ.	μ.	ν.	Cos τ.	μ.	ν.
0·0000	1·000	1·0000	0·8584	2·666	0·4996
0·0466	1·032	0·9696	0·8623	2·698	0·4963
0·1075	1·076	0·9318	0·8661	2·731	0·4930
0·1737	1·128	0·8927	0·8699	2·765	0·4897
0·1974	1·148	0·8791	0·8737	2·800	0·4863
0·2545	1·198	0·8472	0·8774	2·837	0·4828
0·3204	1·262	0·8114	0·8811	2·874	0·4794
0·3420	1·284	0·8017	0·8849	2·914	0·4759
0·3954	1·345	0·7717	0·8885	2·954	0·4723
0·4795	1·456	0·7278	0·8922	2·996	0·4687
0·5000	1·486	0·7171	0·8958	3·040	0·4650
0·5342	1·540	0·6992	0·8994	3·085	0·4613
0·5819	1·607	0·6791	0·9030	3·132	0·4576
0·6113	1·684	0·6580	0·9065	3·181	0·4538
0·6428	1·754	0·6407	0·9100	3·233	0·4499
0·6521	1·775	0·6359	0·9134	3·286	0·4460
0·6716	1·826	0·6245	0·9269	3·526	0·4297
0·6920	1·882	0·6127	0·9397	3·778	0·4079
0·7126	1·943	0·6006	0·9428	3·899	0·4076
0·7332	2·011	0·5881	0·9458	3·986	0·4029
0·7538	2·087	0·5752	0·9488	4·079	0·3981
0·7579	2·103	0·5726	0·9517	4·178	0·3932
0·7620	2·119	0·5699	0·95738	4·395	0·3830
0·7661	2·136	0·5672	0·97048	5·091	0·3551
0·7702	2·153	0·5646	0·97523	5·459	0·3427
0·7743	2·171	0·5618	0·98178	6·159	0·3223
0·7784	2·189	0·5991	0·98481	6·612	0·3186
0·7825	2·207	0·5564	0·98572	6·773	0·3072
0·7866	2·226	0·5536	0·98927	7·567	0·2905
0·7907	2·245	0·5508	0·99090	8·062	0·2814
0·7948	2·265	0·5480	0·99242	8·647	0·2716
0·7988	2·286	0·5452	0·99382	9·352	0·2611
0·8029	2·306	0·5423	0·99511	10·222	0·2497
0·8069	2·328	0·5395	0·99627	11·326	0·2372
0·8110	2·350	0·5366	0·99730	12·789	0·2232
0·8150	2·372	0·5336	0·99776	13·719	0·2155
0·8190	2·395	0·5307	0·99818	14·839	0·2072
0·8230	2·419	0·5277	0·99857	16·220	0·1982
0·8270	2·443	0·5247	0·99891	17·974	0·1882
0·8310	2·469	0·5217	0·99922	20·297	0·1771
0·8350	2·494	0·5186	0·99948	23·552	0·1644
0·8389	2·521	0·5155	0·99969	28·530	0·1494
0·8428	2·548	0·5124	0·99985	37·385	0·1305
0·8468	2·576	0·5093	0·99996	59·344	0·1036
0·8507	2·605	0·5061	1·00000	—	0·0000
0·8545	2·635	0·5029			

* The majority of values in the table were taken from Dr. A. Palmgren's "Untersuchungen über die statische Tragfähigkeit von Kugellagern," adding a few figures given in Herz's original paper, while the figures above cos τ = 0·95738 were added by the author of the present article.

and

$$a = 0{\cdot}198\sqrt[3]{\bar{1}}\ ;\quad b = 0{\cdot}00247\ \sqrt[3]{P}$$

Assuming $\Theta_{max.}$ = 10,000 kg. per square centimetre, as the permissible maximum surface pressure,

$$\Theta_{max.} = 10{,}000 = \frac{3}{2}\frac{P}{a . b . \pi},$$

from which P = 1,080 kg. would be the permissible peripheral force.

The length of the ellipse of contact under a load of 1,080 kg. is given by $a = 0{\cdot}198\sqrt[3]{P} = 0{\cdot}198\sqrt[3]{1{,}080} = 2{\cdot}03$ cm., which is a figure comparable with the line of contact between the teeth of ordinary spur gears. It can also be seen that, in the case of small included angles between the axes of the skew gears, rubbing speed will but slightly exceed the figures occurring in spur-gear drives. In the same example, for instance, the rubbing speed at the pitch circle V_c is given by

$$V_c = R_1\,\omega_1 \sin\beta_1 + R_2\,\omega_2 \sin\beta_2$$
$$R_1 = R_2,\ \omega_1 = \omega_2,\ \beta_1 = \beta_2.$$
$$V_c = 2\,R_1\,\omega_1 \sin 6 \text{ deg.} = 0{\cdot}209\,R_1\,\omega_1.$$

In the plane of rotation, the rubbing speed in the pitch circle is zero. For comparative purposes, let the rubbing speed at the top of the tooth be taken in the plane of rotation in normal spur gears. This may be calculated, as shown in Fig. 14, opposite since

$$V_c{}^1 = (\omega_1 + \omega_2)\,\xi$$

$$\frac{R_1 \cos 15 \text{ deg.}}{R_1 + m} = \cos\kappa\ ;\ \kappa = 23^\circ\,5'\,50''$$

$$= R_1(\cos\phi\tan\kappa - \sin\phi) = R_1 \times 0{\cdot}1517$$

$$V_c{}^1 = 2\,\omega_1 \times 0{\cdot}1517\,R_1 = 0{\cdot}3034\,R_1\,\omega_1.$$

It is thus seen that the rubbing speed in the pitch circle of a skew-gear drive of comparatively small angle may be even less than at the top of the teeth of an ordinary pair of spur gears of the same dimensions and at the same number of revolutions. Even if to this be added the rubbing speed arising in the plane of rotation and conditions similar to the spur-gear drive be referred to the top of the teeth, the comparison will not be changed essentially, as this other rubbing speed in skew gears will also be of nearly the same amount as in spur gears, and hence even the resultant rubbing speed will exceed that of the spur-gear drive by only about 20 per cent. Conditions will thus be almost identical with those of a spur drive of about 20 per cent. higher speed. It is remarkable that a force of the order commonly transmitted by spur gears or bevel gears, may, according to the calculations, also be transmitted by skew gears. It may be assumed that a calculation being available for determining the maximum pressures arising in the teeth of skew gears, it will be possible to substitute skew gears in certain cases for bevel-gear drives, where, for some reason this type of transmission appears to be more convenient.

LITERATURE.

Sound. By DR. E. G. RICHARDSON. Third edition. London: Edward Arnold and Company. [Price 16*s.*]

CONTINUED interest in the study of sound, and particularly in its technical applications, makes a periodical revision of any text-book on the subject desirable. In this latest edition of Dr. Richardson's *Sound*, first published in 1927, the chief additions have been to the chapters on acoustic impedance, supersonics and sound reproduction. Now, brought up to date again, it will continue to serve as one of the most useful and reliable of introductory acoustical texts.

The classical groundwork is concisely covered in chapters on the calculation and experimental determination of the velocity of propagation of sound in fluid media, on the theory of simple and coupled vibrating systems, on longitudinal and torsional vibrations in solids, on the transverse vibrations of strings, rods, plates and membranes, and on the longitudinal vibrations of columns of air in pipes. Dr. Richardson's own investigations make the chapter on "Vortex Formation and Aeolian Tones," especially noteworthy. Brief, but interesting, points of detail concerning representatives of the various classes of orchestral instruments are included. Heat-maintained sounds, interesting for the light they shed on the process of maintenance, are also considered. The section on the analysis of sound in air serves to indicate the great benefit that has come to acoustics from its association with electricity; as a recorder of sound-wave profiles, the cathode-ray oscillograph has ousted even the most highly perfected of mechanical recorders, and the revolution in the fidelity of sound reproduction by electrical loud speakers through the agency of electrical pick-ups from electrically-cut records has been one of the outstanding scientific achievements of the past fifteen years. The chapter on the definition and measurement of acoustic impedance is welcome, since the implications underlying the transposition of the electrical term into an acoustical context are proving increasingly fruitful in practice.

The advanced study of sound involves a good deal of solid mathematical analysis. In an introductory text, chiefly stressing the physical side of the subject, this analysis has rightly been kept as simple as possible. There are occasions, however, such as the derivation of the Sabine reverberation formula, in which the analysis has been oversimplified. The calculation of the amount of energy falling per second on unit area of a wall bounding an enclosed space in which the existing sound energy is in a completely diffuse state is a three-dimensional problem—and not, in fact, an unduly difficult one. Dr. Richardson has avoided it by making a statement, on page 298, which should certainly be removed from a subsequent edition, namely, that "the average value of cos δ when δ lies between 0 deg. and 180 deg. is $\frac{1}{4}$"! Very complete references to original papers are provided at the foot of nearly every page in the book. These appear generally to have been judiciously chosen, though a few seem to bear little relation to the accompanying text; thus, in connection with the discussion of the transverse motion of a string stretched between fixed terminal supports and plucked at an intermediate point, references are given, on page 74 and on page 87, to a paper by Carrière, which is concerned with investigating the crack of a whip. These, however, are matters that can easily be rectified and detract not at all from the real merit of Dr. Richardson's work.

Boiler House and Power Station Chemistry. By DR. WILFRED FRANCIS. London: Edward Arnold and Company. [Price 15*s.* net.]

THIS book has been written to provide chemists, students of fuel technology, and those in charge of boiler plant at power stations with an introduction to the chemical consideration involved in the combustion of coal and the operation of steam power plant. In general, it can be described as good but insufficient; it might have been greatly improved by the addition of, say, another 100 pages, to allow of the inclusion of much information which has been omitted. The first part of the book deals, in somewhat elementary fashion, with such well-worn subjects as the constitution of coal, its natural impurities, the properties of what the author calls "commercial coals," and the efficiency of combustion, including methods for calculating the efficiency of the performance of boiler plant—which, however, is dealt with in a somewhat involved fashion. There is also a chapter on flue-gas treatment, a subject in which the author has had extensive practical experience, having been formerly chief chemist of the Fulham Borough Council. In view of this special qualification, it seems unfortunate that such an important and interesting subject should be dealt with only very briefly.

The author makes no reference to the significant experimental and development work that has been carried on for many years, by Professor H. F. Johnstone and his associates at the University of Illinois, on the elimination of sulphur compounds from chimney gases. He rightly emphasises that those responsible for the installation of the combustion-gas purification plants at Battersea, Fulham, and Swansea power stations deserve credit for being pioneers in a national cause. There seems, however, to be no indication that any other power undertaking in the world intends to adopt these methods in the immediate future; and there is still much to be said for the high chimney, say, 300 ft. to 350 ft. Further, in connection with this chapter, the author deals well and concisely with such subjects as scale formation, water softening (with no reference, however, to the latest "Zeo-carb" system of zeolite treatment), corrosion and caustic embrittlement; but the chlorination of cooling water is dealt with in a single page, and without giving any description of the equipment illustrated. Incidentally, mussels in circulating-water pipes are not killed by chlorination, as is stated in the book; the chlorination kills the minute organisms on which mussels live. We have not previously heard of the use in "bursts" of anything like 30 parts of chlorine per million, the usual figure being much less than 10 parts.

The chapter on turbine, switch and transformer oils is excellent, and there is much that is good in the second part of the book, which has been written to provide chemists with full details of all the analyses undertaken in normal boiler-house practice. It is difficult to understand why, however, in a chapter on flue-gas analysis, there is not even a mention of one of the most vital instruments in the whole field of the scientific control of boiler plant, namely, the combustion recorder; although there is a reference to a sulphur-dioxide recorder.

THE ROAD TUNNEL UNDER THE RIVER MAAS AT ROTTERDAM.

By J. P. Van Bruggen.

(*Concluded from page* 164.)

The Land Tunnels.

The covered land tunnels consist essentially of reinforced-concrete tubes, of rectangular cross section, provided with a division wall forming two passages, each of which serves for one-way traffic. The tubes, a cross-section of one of which is given in Fig. 38, on Plate XVII, are rendered watertight by means of four layers of waterproof paper separated from each other and encased in five layers of bitumen. As shown in Fig. 38, the ventilating ducts are placed over the roadway passages, in order to minimise the depth of the excavations in which the tubes are situated. Each tube was constructed in an open trench, the walls of which were retained in position by means of sheet-piling. The trench was kept dry by lowering the ground-water level. On the right bank, the condition of the ground was sufficiently satisfactory to enable the tunnel to be built directly on the bottom of the trench; on the left bank, a pile foundation was necessary.

The form and methods of construction of the tunnels were so simple and straightforward that no preliminary investigations were necessary in connection with them. Consideration was, however, given to the possibility of economy resulting from the employment of an arch form for both the roof and sole, but this arrangement was not adopted because with a tunnel sole of this type a deeper trench would have been necessary and in the case of the roof there would have been difficulty in fitting the watertight layer which is enclosed in the concrete. The question of shortening the covered tunnels and increasing the length of the open approach ramps was also considered, as this would have reduced the amount of ventilating plant and artificial lighting required. This procedure would not have been possible on the left bank as a street passes over the outer end of the tunnel. On the right bank, piling would have been necessary with permanent supporting cross members. As the economy obtained by the adoption of such an arrangement would have been comparatively small, and the appearance would not have been altogether satisfactory, it was not adopted.

The trench in which the tunnel was constructed was necessarily fairly wide, but in order to keep it as narrow as possible the sheet piling which supported the sides was used as shuttering for the tunnel concrete. The restriction of the trench to the least possible width favourably influenced the dimensions of the cross-shores and avoided a difficulty which would have been encountered had the tunnel been constructed in a wider trench. In that case, it would have been necessary to leave temporary openings in the concrete construction to accommodate the shores, with the result that difficulty would have been experienced in placing the watertight layer. The alternative method of replacing the shores by short packing blocks supported against the completed part of the concrete work, would have meant that special measures would have had to be taken at these points in order to ensure that the necessary uniform pressure was applied to the watertight layer. The method of working adopted made it impossible to withdraw the sheet piling when the work was completed, but even with the alternative method this procedure would have introduced the possibility of damaging the watertight layer unless the staging of the shuttering had been very heavy. It could not in any case have been adopted without very serious consideration.

When excavating the trench for the tunnel, the normal ground-water level was met at a depth of 3 m. A series of well shafts, 35 cm. in diameter, were then sunk in the neighbourhood of the trench and equipped with under-water pumps, the positions and numbers of the wells being determined on the results of preliminary test pumping, which indicated

RIVER MAAS ROAD TUNNEL, ROTTERDAM.

Fig. 43.

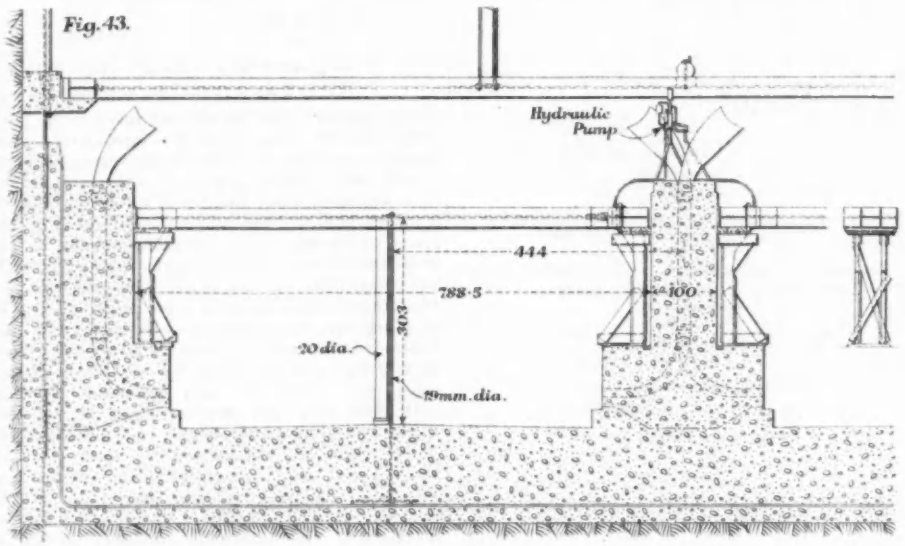
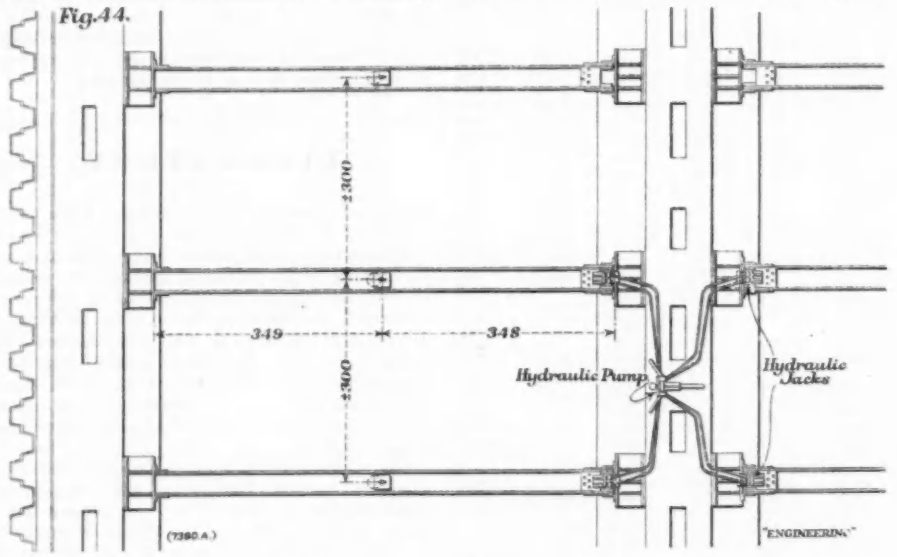


Fig. 44.



that the underground water had to be considered as artesian water. Normally, during the construction of the tunnel, 19 wells were kept in operation on each bank, the delivery from each being 75 cub. m. per hour. This equipment lowered the water level by 15 m. measured at the deepest part of the trench. It was interesting to find that the neighbouring harbour, and also the river, had such impervious bottoms that the lowering of the ground-water level was unaffected by them and took place as it would have done had the neighbouring area been of solid earth. In order to conserve the impermeable bottom of the river as long as possible, the programme of work was arranged so that the dredging of the trench for the under-water tunnel was postponed as long as possible, to facilitate the ground-water lowering operation. Actually difficulties due to this disturbance proved less than had been expected, the effects of breaking through the impervious layer disappearing in a few days; the bed evidently silted up again.

The wells were situated outside the sheet piling, as shown in Fig. 45, opposite, which is a cross-section of the work and neighbouring ground, the approximate form of the ground-water table being indicated. This position, by keeping the pumping installation well away from the work being carried on inside the trench, prevented interference with that work and at the same time secured the installation from accidental damage. It also had the advantage that the relatively impervious ground layers above the strata containing the water under pressure could be gradually de-watered at the same time, thus reducing the load on the sheet piling. As the purpose of the installation was to deal with water under pressure, the choice between the arrangement of the plant either inside or outside the trench was not of much importance from the point of view of the main body of water concerned or the depth of ground-water lowering. The pile-drivers for the Larssen sheet piling were erected inside the trench after it had been excavated to the depth of the surface layers. The dimensions and driving depth of the piles were determined as the result of soil-mechanics investigations. It was necessary that they should penetrate into the solid ground, which carried the whole load of the tunnel, in order that there should be no danger of them sinking or becoming displaced owing to the consolidation of the upper layers following the lowering of the ground-water level.

On the left bank, after the trench had been carried to the depth of the surface layers, the foundation piles for the tunnel were driven. This operation, which is illustrated in Fig. 39, on Plate XVII, was carried out before the sheet piling was in place. The reverse procedure might have resulted in the sheet piling becoming displaced owing to the outward pressure of the earth. The driving of the foundation piles at this early stage in the excavation of the trench had the important advantage that it was not necessary to operate the ground-water lowering plant, and the difficulties which might have attended the driving of piles between the shores of a deep construction trench were avoided. In order that this procedure should not require the use of

ROAD TUNNEL UNDER THE RIVER MAAS, ROTTERDAM.

Fig. 45.

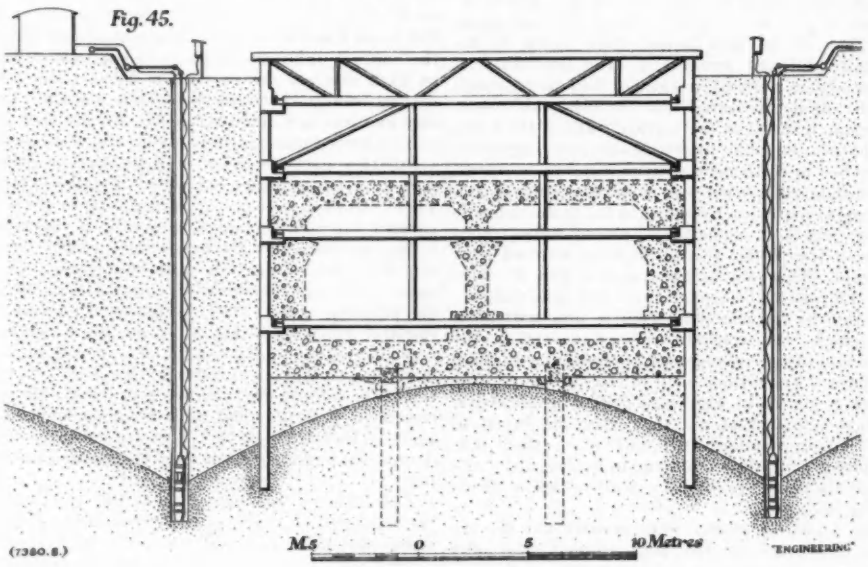


Fig. 46.

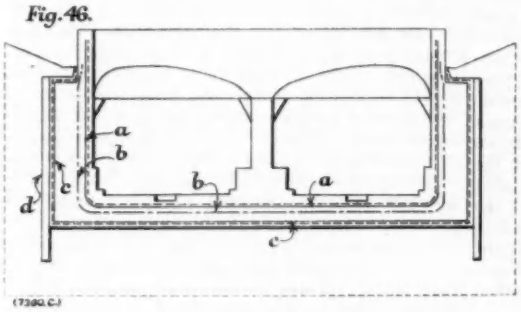
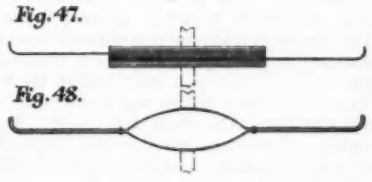


Fig. 47.

Fig. 48.



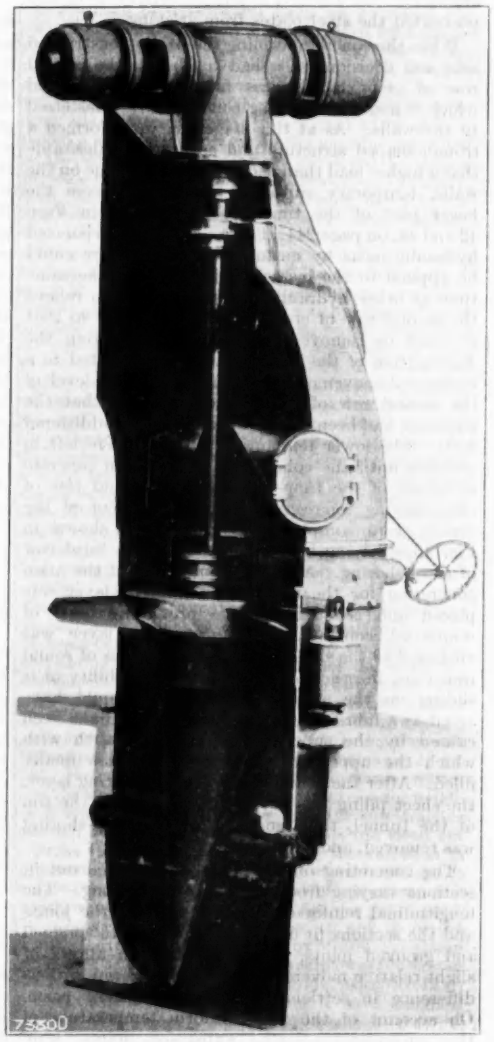


FIG. 49. MODEL OF VENTILATING FAN.

unnecessarily long piles, the upper portions of which would ultimately have had to be cut off, the work was carried out with Franki piles. These were concreted only to a height of 60 cm. above the necessary final length, the upper part of the holes formed by the driving operation being filled with sand. A preliminary test, in which six piles were driven and partly excavated, showed that, in the fairly soft earth concerned, any increase of the pile shaft diameter due to the driving procedure, such as might have deformed the reinforcement, was insignificant and that neighbouring piles were not displaced by the driving of others. The correct driving of the piles was controlled by means of a steel wire attached to the pile reinforcement at one end and carrying a counterweight at the other, the wire passing over a pulley at the top of the pile-driver.

The construction of the cross-shoring for the trench was carried on as excavation proceeded. In view of the large forces involved, this was of steel construction made up of a series of rigid individual units, broad-flanged beams being used to a considerable extent. In designing this shoring two opposing considerations had to be kept in mind. On the one hand, it was desirable that the sheet piling, which would not be recovered, should not be heavier than necessary, and on the other hand, it was desirable that the shoring should be as light as possible in order to offer the minimum interference with the work being carried on in the trench. As shown in Fig. 45, the upper cross-member was of lattice construction and was carried by concrete saddles resting on the top of the sheet piling. The lower bracing, consisting of horizontal cross-members, the ends of which butted against longitudinal joists, was supported from the lattice girder by means of hangers. Owing to small inaccuracies in the driving of the piles, and to the fact that the width of the tunnel is greater on curves, the space between the longitudinals and the sheet piling varied in width, the steelwork being of uniform dimensions throughout the work. This space was accordingly filled in with hardwood wedges and lengths of round timber. In order that this procedure should not introduce the possibility of buckling, the round timber was replaced by concrete saddles opposite the ends of the cross shores. Arrangements were made to measure the load on the horizontal cross members by inserting hydraulic jacks between the longitudinals and their ends. The measurement was carried out at regular intervals.

When the excavation was completed, men, working in the space below the lowest row of cross shoring, placed a layer of concrete over the trench bottom and when this was set, spread an asphalt-felt watertight coating over its surface. The asphalt-felt was then protected by a thin layer of concrete, and the placing of the concrete tunnel sole was proceeded with. The application of the asphalt layer, which is to the German standard DIN 4031, is illustrated in Fig. 40, on Plate XVII. The underside of the sole of the tunnel is formed in steps in order to eliminate the possibility of it sliding in a down-hill direction as a result of the asphalt layer acting as a lubricant. The risers of the steps are formed at an angle of 45 deg., in order to ensure that all parts of the watertight layer are under pressure. Were there any possibility of the watertight layer stretching or swelling, water might be drawn in, with the result that the felt would ultimately rot. As an additional security against sliding action, the treads of the steps are given a counter-slope of 1 in 200. Full-scale experiments were made in order to determine the best way to arrange the necessary overlapping of the felt layer at corners, as it was necessary to arrange that there should be no voids through which pressure water might make its way.

From the time that the excavation had been carried to the depth of the pressure water until the tunnel structure was completed, it was essential that there should be no failure in the arrangements made to keep down the ground-water level. Any such failure, by subjecting the tunnel sole, or the partly-completed tunnel, to the action of the pressure water, might have resulted in serious damage. In order to eliminate this danger, without going to the expense of installing reserve pumping and generating plant, relief wells were bored inside the trench. Two of these are indicated in Fig. 45. These provided a vent through which pressure water below the base of the tunnel might escape and flow into the trench; after the placing of the sole, it would spread itself over the concrete surface in which suitable openings were left. When the main concrete work of the tunnel was completed, and the ground-water lowering plant was dismantled, these wells were plugged.

When the sole of the tunnel had hardened sufficiently, the lowest row of cross-shoring was dismantled so that the load it had carried was transferred to the sole. Working below the next row of shoring, the lower parts of the side and division walls were then constructed. The first stage in this latter operation was the application of a protecting layer of concrete to the face of the sheet piling and the securing of the watertight layer over this. While this work was being carried out it was noted that the pressure air, which was used in the construction of the ventilation building several hundred metres away, had made its way underground and, in places, had forced the watertight layer away from the protecting layer of concrete to which it was attached. Work on the watertight layer was accordingly temporarily suspended. The compressed-air plant was then shut down and the loose areas of the watertight layer were dealt with by heating the material and pressing it back into its original position. Heating was carried out by applying steel plates, covered

with aluminium foil on their inner faces, to the affected parts. Hot sand was then brought into contact with the outer faces of the plates. The aluminium foil adhered to the watertight layer and prevented the steel plates from sticking.

When the concrete forming the partly-constructed side and division walls had hardened, the second row of cross-shoring was taken down, the load which it had carried being consequently transferred to the walls. As at this stage the work formed a trough-shaped structure and as it was undesirable that a higher load than necessary should come on the walls, temporary supports were built across the lower part of the tunnel, as illustrated in Figs. 43 and 44, on page 244. These supports incorporated hydraulic jacks by means of which pressure could be applied to the inside of the walls, at the same time as other hydraulic jacks were used to relieve the second row of cross-shoring from load, so that it could be removed. During this operation the deformation of the concrete work was limited to a horizontal movement of 0·15 mm. at the level of the second row of cross-shores, showing that the structure had been subjected to very little additional load. The lower temporary supports were left in position until the completion of the main concrete structure of the tunnel. With the second row of cross-shoring removed, the walls and roof of the tunnel were completed, this work, as shown in Fig. 45, all lying below the level of the third row of cross-shoring. After the completion of the main concreting for the roof, the watertight layer was placed and covered with its protecting layer of reinforced concrete. This protecting layer was anchored to the sheet-piling wall by means of round iron rods, in order to eliminate the possibility of it sliding on the asphalt layer, which would have acted as a lubricant. This sliding might have been caused by the superimposed mass of earth with which the upper part of the trench was finally filled. After the completion of the protecting layer, the sheet piling was cut off at the level of the top of the tunnel, the remainder of the cross-shoring was removed, and the trench was filled in.

The concreting of the tunnel was carried out in sections varying from 12 m. to 40 m. long. The longitudinal reinforcement runs through the joints and the sections fit one into the next with tongued and grooved joints. This construction allows of slight relative movements, but prevents any serious difference in settlement between adjacent parts. On account of the very uniform temperature of the surrounding earth, expansion joints were considered to be unnecessary, while the method of construction in sections obviated any difficulty from the effect of initial shrinkage. The watertight layer runs unbroken through the joints, but is reinforced at the joints with strips of corrugated copper 0·2 mm. thick and 0·6 m. wide. A view inside the tunnel after the completion of the main concrete work, but before the interior finishing had been carried out, is reproduced in Fig. 41, on Plate XVII.

Approach Ramps and Escalator Shafts.

The open approach ramps consist of trough-shaped reinforced-concrete structures carried on piles. The deepest parts of these ramps reach to a depth of about 5 m. below ground-water level. Owing to this relatively small depth, watertight casings for the ramps were not considered necessary. The upper portions of the piles, above ground-water level, are of reinforced concrete, the remainder being of wood. The sole-plates of these ramps were made in sections 42 m. long. One of these sections during the placing of the concrete is illustrated in Fig. 42, on Plate XVII. Copper plates are inserted in the joints between the sections, to make them watertight. The plates are of "fish-bladder" form in cross-section and permit of slight relative movements of the sections in the direction of the tunnel axis. This form of joint is illustrated in Fig. 48, on page 245. A variation in settlement in a vertical direction between the sections was considered improbable owing to the rigidity of the pile foundations. Any relative movement in a horizontal direction, at right angles to the tunnel axis, due, for instance, to unequal earth pressures on the two sides of the structure, is prevented by bosses formed on the end of one reinforced-concrete section, which lock into corresponding recesses in the next section.

Particular attention, especially on the right bank, had to be paid to the joint between the open ramp and that of the land tunnel, these being fundamentally different structures. The possibility of differences in vertical settlement had to be considered. As it was feared that the fish-bladder construction, inserted in the vertical walls of the joint, would not be able to withstand any important difference in settlement without rupture, a second water-tight connection was made consisting of two flat copper plates, each inserted in one of the elements to be joined. Asphalt-felt sheets were placed between the plates, the whole being encased with concrete. This joint is illustrated in Fig. 47, page 245. Flexure of the asphalt layer will alow this construction to accommodate itself to any settlement differences, the concrete casing preventing the formation of any passages for ground water through the joint. The arrangement of the various jointing layers is shown in Fig. 46. The outer sheet-pile wall is indicated at *d*; the watertight layer, to the German standard DIN 4031, at *c*; the "fish-bladder" joint, shown in detail in Fig. 48, at *b*; and the overlapping copper-plate joint shown in detail in Fig. 47, at *a*.

The escalator shafts were constructed on the same principles as the land tunnels, the only important difference being that the watertight layers in the roof and sole were formed in small steps. The shafts are supported on wood piles, as is indicated in Fig. 34, page 163, *ante*. It was considered undesirable to adopt inclined Franki piles for the support of this structure without considerable preliminary investigation, for which time was not available. The piles were driven with their heads to their final level before the excavation of the trench in which the shaft was built. For this operation a long steel cylinder was fitted over the pile head, the cylinder containing a loose ram which was operated by the pile driver. In order that the piles, when driven below the surface of the ground, should be properly guided, the steel girder enclosed the head of the pile for a length of 3 m.

Lighting, Ventilation, Etc.

The architecture of the ventilation buildings and tunnel portals is of simple type, the desired effect being obtained by the form of the constituent masses. No attempt has been made to avoid flat concrete surfaces, but the uninteresting effect of large areas of this type has been eliminated by covering them with corrugated sheeting. The satisfactory placing of this sheeting required considerable care, as it is apt to be somewhat irregular in cross section. The surface of the outer walls of the buildings which are within hand reach are covered with a facing of artificial stone. The sections of this covering layer are formed with dove-tail projections on the inner side in order to anchor them securely to the wall behind.

The surfaces of the roadways are formed of hard-baked yellow bricks. These are laid directly on the reinforced-concrete tunnel sole; in other places they have a rolled macadam foundation. The yellow colour of the bricks has the advantage that if sodium lamps are adopted for artificial lighting, objects on the roadway will be seen with the maximum possible contrast. The use of this type of lighting is very probable, but a decision depends on the development of lighting technique in the next few years. The lamps will be fixed in lanterns as high as possible on the side walls of both the motor-traffic tunnels, and the pedestrian and cyclist tunnels. At the tunnel entrances, this lighting will be augmented by means of rows of lamps on the ceiling. To assist the lighting, ceramic panels of clear colour and good reflecting quality are fixed to the walls. It was at first intended that this type of covering should also be fixed to the tunnel ceilings. The idea was, however, abandoned as even with the best conceivable method of fixing the panels, absolute security against the falling of a panel could not be guaranteed and a fall of this kind might cause a very serious accident. The most suitable type of covering has not yet been determined.

The ventilation of the motor-vehicle tunnels is effected by air currents delivered across the traffic stream. Fresh air enters close to the roadway, the foul air being withdrawn at roof level. The air ducts are shown in the tunnel cross section given in Fig. 6, on Plate VIII, *ante*. The central duct below the roadway takes the fresh air supply, while those on each side are the extraction ducts. The connecting passages between these ducts and the roadway and roof are indicated in Fig. 6. Each of the two roadway tunnels is divided into four sections for ventilation purposes, each of these sections being served by two pressure fans and two exhaust fans. These can be run either individually or in pairs in parallel, but as a single fan is capable of supplying to its associated duct the maximum quantity of air required, the second fan may be regarded as a spare. The fans, of which there are 32 in all, are of the propeller type. They are mounted on vertical spindles, as shown in Fig. 49, page 245, which is a reproduction of a photograph of a model of one of the fans and its associated driving gear. At the top of the fan spindle there is a gear drive with two electric motors mounted on a common horizontal shaft. The motors are of the two-speed type, with double windings, and either may be used to drive the fan.

The fans are so designed that they will deliver the estimated quantity of air required at their maximum efficiency; if found necessary, however, the output can be altered by rotating the fan blades about their axes. The largest fans are designed to deliver 349,000 cub. m. of air per hour. When the tunnel is in full operation, the total quantity of air required will be 1,975,000 cub. m. per hour. The initial installation, which will have motors up to 50 h.p. and a total motor horse-power of 980, including the spares, when in full operation, will be capable of delivering this quantity, but in the future it will be necessary to extend the installation so that this quantity may be delivered without running the spares.

The pedestrian and cyclist tunnels will be ventilated by delivering fresh air at various points in these passages and extracting it through the escalator shafts. The greatest velocity of the air flowing through the tunnels in the direction of their length will be 0·15 m. per second. The maximum total quantity of air required will be 30,000 cub. m. per hour and will be supplied by two centrifugal fans, one situated in each of the ventilation buildings. No spares will be installed.

The form of the main air ducts, and of the branches connected to them, with particular reference to the resistance to air flow which they would introduce, was investigated in great detail. The work was carried out in conjunction with the Department of Aero- and Hydrodynamics of the Technical University at Delft. Investigations were made on various ventilation installations and the calculations involved were based on records of work carried out over many years. In connection with the operation of the ventilating installation for the motor-vehicle tunnels, carbon-monoxide indicating instruments are being installed, arranged in such a way that the carbon-monoxide present in two main exhaust ducts may be determined alternately. Initially, there will be four indicating instruments, but it is possible that when the tunnel is in full operation it may be found desirable, in order to obtain the best results, to install other recording instruments in addition, such as smoke recorders and traffic counters.

Among other features of the tunnel equipment to which reference should be made, are the escalators serving foot passengers and cyclists. There are eight of these, the vertical distance between the top and bottom being 17 m. The escalators are arranged to run in either direction, so that the service provided may be adjusted to suit the traffic conditions. In the daytime it is intended that one or more of the escalators shall run continuously; at night they will be automatically set in operation as required by a photo-electric cell arrangement, a light beam being interrupted by the person desirous of using the escalator. A lift is provided in each ventilation building for the use of the tunnel-operating staff.

There are three pumping installations, one in each

SIDE DRAGLINE ATTACHMENT FOR EXCAVATORS.

MESSRS. PRIESTMAN BROTHERS, LIMITED, HULL.

Fig. 1.

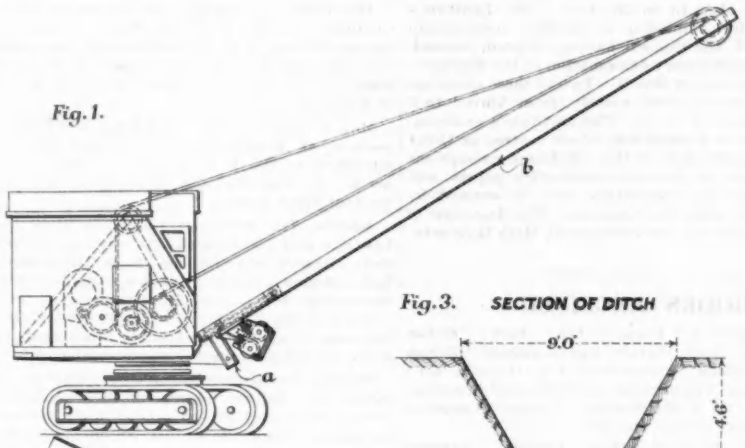


Fig. 3. SECTION OF DITCH

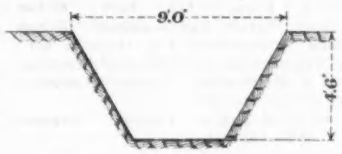
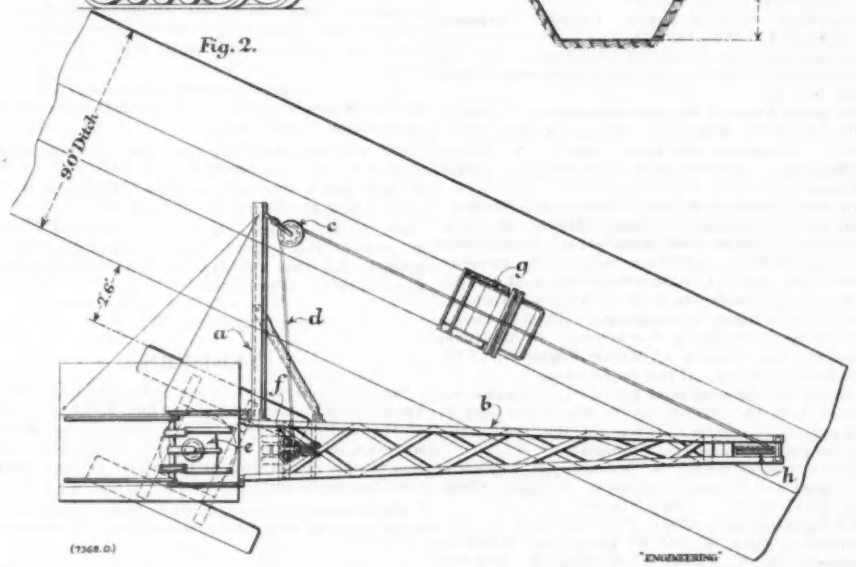


Fig. 2.



of the ventilation buildings, and one situated in the middle of the river section of the tunnel. These deal with any leakage water and with water used for washing down or for fire-extinguishing purposes. The installations are provided with gear for automatic operation. Rain-water falling on the open ramps and the parking places is collected in gulleys running along the parapets and thence is led to sumps in the ventilation buildings and to the other pumping stations, which are situated near the traffic roundabouts.

The electrical installation is operated from a central station from which all the moving machinery, as well as the traffic signals, can be controlled. The station contains high- and low-tension plant, an accumulator battery, the traffic-signal apparatus and a telephone call station. In addition to the central control, all moving machinery can be started or stopped on site and the traffic signals can also be operated by the traffic officials in the tunnels. The tunnel equipment will include special vehicles available for towing any cars or lorries which may break down in the tunnel. The sanitary and fire-fighting equipment, together with a telephone installation, will be situated in niches formed in the tunnel walls.

The order for the carrying out of the greater part of the work described above was placed by the City Authorities on February 2, 1937. The contract was undertaken by the Dutch Co-operative Building Society, which subsequently adopted the name N.V. Maastunnel. Work on the site was started on June 15, 1937, and if the programme could have been carried out as originally arranged, it would have been completed in the summer of 1941. Making no allowance for the variation in the value of the Dutch guilder between the presentation of the tender and its acceptance, the estimated cost of the work was as follows :—

	Florins.
Buildings and installed plant	12,324,900
Various fittings	75,000
Motor vehicles	33,000
Auxiliary work in river	64,000
Road alterations and roads	1,100,000
Track alterations	100,000
Demolition of existing buildings	206,770
District rates	50,000
Design and supervision	620,000
Extras...	526,330
	15,100,000

It was estimated in the summer of 1939 that the actual cost would be some 20 per cent. higher than the figure given above, but subsequent events obviously will have rendered the estimates, both of costs and date of completion, of little value. The designs were worked out with full collaboration between the municipal authorities, the N.V. Maastunnel, and others who participated in the actual work.

NEW YORK WORLD'S FAIR.—The World's Fair at New York which was opened on May 11, is to close on Sunday, October 27.

ROYAL AERONAUTICAL SOCIETY.—The Elliott Memorial Prize has been awarded by the Council of the Royal Aeronautical Society to aircraft apprentice R. Burrows, who, last year, obtained the highest marks in the General Studies Examination.

SIDE DRAGLINE EXCAVATOR.

IN our issue of July 19, in a leading article discussing the drainage of agricultural land, we expressed the view that the operation of ditching called for a simple machine in the form of a light-weight side-bucket dredger mounted on a creeper track and, further, stated that we believed such a machine to be not yet in existence. Although we see no reason to withdraw the latter statement, we are glad to be able to record a successful approach to the machine visualised in the side dragline attachment developed by Messrs. Priestman Brothers, Limited, Holderness Foundry, Hull, which attachment can be readily fitted to the firm's standard excavators with creeper-track mounting. This attachment is shown in operation in Figs. 4, 5, and 6, on page 250, and its construction is illustrated in Figs. 1, 2, and 3, on this page. In the first place, it must be realised that there is nothing to prevent a narrow ditch or trench being cut by the ordinary dragline provided the excavator can be run back along the line of the cut on the untouched ground. A large part of ditching is, however, concerned with the cleaning and deepening of existing ditches and these are mostly too narrow to allow the scoop to work transversely in the usual manner. It would be impossible to traverse an excavator along the line of the ditch unless the impracticable construction of abnormally separated creeper tracks were adopted. Again, the machine should be capable of being traversed along the ditch at some distance from the edge, otherwise its weight might cause collapse of the bank and it should be capable of working wholly on one side of the ditch since, very often, the opposite side may be close against a hedge.

It will be clear from Fig. 4 that the side dragline attachment permits the excavator operating it to be traversed with complete safety along the edge of a pre-existing ditch and from Fig. 5 that the ditch can be cleared close up to a hedge or a row of trees. The machine is shown in Fig. 4 at work on cleaning a drain of 8 ft. 6 in. in top width, 2 ft. 6 in. in bottom width, a depth of 5 ft. 6 in. of soft peat and clay being removed. The output ranges from 7 chains to 10 chains per 10-hr. day. Naturally, however, the performance varies with the size of the machine; thus, an excavator weighing 7 tons to 8 tons, provided with the side dragline gear and a 5-cub. ft. to 6-cub. ft. scoop, can clean out 5 chains to 10 chains per 10-hr day, the variation in output depending on the amount of material to be removed per lineal yard. The cost of operation, it is stated, works out to from 3*d.* to 5*d.* per cubic yard. The excavator illustrated in Figs. 1 and 2 is the ¼-cub. yd. capacity machine made by Messrs. Priestman and known as the "Cub." This machine was illustrated and described in ENGINEERING, vol. 136, page 540 (1933) so that little further comment on it as a standard machine is necessary, except to mention that its weight in working order is 7½ tons, the resultant ground pressure being 8 lb. per square inch; and that it can be modified to operate as a dragline, a shovel, a skimmer, a grab, a crane, or a trencher. It may be noted, further, that in the last-mentioned capacity trenching is done by a scoop attached to an arm pivoted on the jib, and that a trench 2 ft. 6 in. wide by 8 ft. deep, has been cut in hard gravel at the rate of 100 cub. yd. in 8 working hours. The trenching, when the machine is thus equipped, is, of course, done with the excavator moving on solid ground as the machine runs back along the centre line of the cut. The side dragline equipment further extends the utility of the machine by its ability to move along a cut already made. A cross-section of the type of ditch dealt with is shown in Fig. 3.

Dealing now with the side dragline gear, as shown in Figs. 1 and 2, it will be seen that an arm *a* is attached to the base of the jib *b*, approximately at right angles thereto. This arm is supported against the pull of the drag by a tubular compression strut attached to the jib and by tension stays with turnbuckles attached to the superstructure. The outer end of the arm carries a snatch-block *c*. The usual drag rope *d* passes from the drag-rope barrel *e*, round a pulley *f* at the base of the jib, over the snatch-block *c* to the scoop *g*. The scoop is suspended by a rope passing over the jib head sheave *h*. When the machine is at work the superstructure is slewed so that the head sheave and snatch block lie on the centre line of the trench as shown in Fig. 2. The dispositions of the ropes can best be made out in Fig. 5. The cycle of operations, viz., lowering, filling, swinging and discharging the scoop, is that followed in normal dragline operation. The filling of the scoop, however, imposes a torque on the superstructure of the excavator, so this is locked in place by a hand-operated "sprag" which engages with the teeth of the slewing rack of the revolving gear.

It will be clear from a comparison of Figs. 4 and 5 that the side dragline gear can be mounted equally well on either side of the excavator, so that the scoop may be operated from either bank and in either direction along the ditch. The equipment can be mounted in

the field. It will also be clear that the spoil can be deposited on the same side of the ditch as that on which the excavator is working or on the opposite side, the first-mentioned condition being seen in Fig. 5 and the last-mentioned one in Fig. 4. In this latter illustration, the scoop is seen to be working squarely on the bottom of the ditch, but it can be worked partly on its side so as to clean up the base of the bank as well as the bottom. With this method of working a man with a spade trims the upper part of the bank and allows the material to fall to the bottom for the scoop to pick up. The spoil may be left on the bank, delivered directly into carts, or, in cases where it is desired to spread it over the adjoining land, this can be done by means of a scraper plate, as shown in Fig. 6. The excavator is of the fully-revolving type, which gives a wide spreading range.

JOINTING MATERIAL FOR DRAINAGE AND WATER MAINS.

A NEW product, known as Philplug jointing material, has recently been placed on the market and will be distributed by Messrs. The General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2. This material is intended as a substitute for lead and is produced both in the ingot and fibrous forms for all classes of caulking and packing. We understand that it has already been accepted by the War Office and Air Ministry for use in all types of spigot and socket joints on drainage, water and other mains. It can also be used, it is claimed, for making joints between flanged pipes, making good between metal heating panels, setting tiles and fire bricks, making joints between electric-light standards and their cast-iron bases, and in other places where lead is normally employed.

Tests have been carried out at the Building Research Station to show that the resistance to permeation of air and of water is greater than with lead-fibre packing and the following is an authorised summary of the report: Two types of test were carried out for permeability to air under pressure and to water under pressure, respectively. Comparative tests with a normal joint using tarred jute and lead fibre were also made. For the first test "a spigot and socket joint was made on a cast-iron pipe and when twenty-four hours old was subjected to a pressure of 12 lb. per square inch. The Philplug joint was markedly superior to ordinary lead-fibre joints as far as permeability to air pressure was concerned." In the second case, the joints were submitted to a pressure of 30 lb. per square inch. There was no measurable leakage even when the pressure was increased to 60 lb. per square inch. "The tests described above have shown that the new Philplug jointing material compares favourably with the commonly used lead fibre and tarred jute in resistance to permeation both of liquid and vapour."

From the economic point of view, Philplug has the advantage that by its use a saving of about 40 per cent. can be effected in the cost of joints compared with lead. Another advantage of this material is that it does not require heat to make it ready for jointing, the addition of water to the dry material in the form in which it is sold rendering it immediately useable. It is both fire and waterproof and is also unaffected by weak acids, concentrated salt solutions, and petrol. It is sufficiently resilient to take up any contraction and expansion that may occur and is easily caulked in any position either by hand or pneumatically.

BRITISH COAL IN ARGENTINA.—Imports of coal into Buenos Aires in July amounted to some 230,000 tons, of which 202,644 tons came from British ports, 20,562 tons from the United States, and the remainder from Chile.

DELORO STELLITE CUTTING TOOLS.—The cutting-tool material known as Deloro Stellite is a non-ferrous metal alloy of cobalt, chromium and tungsten which was originally developed a few years before the war of 1914-18, by Messrs. Deloro Smelting and Refining Company, Limited, Deloro, Ontario, Canada. The properties of of the material and the manner in which it is used are described in an illustrated brochure recently published by the sales office and works of the Company in the United Kingdom, the address of which is Highlands-road, Shirley, Birmingham. The standard grade of the alloy is known as Stellite 40 and this is suitable for most operations. A new alloy, described as Grade 80 Stellite, is mentioned in the brochure. This is stated to have the same general characteristics as Grade 40, including ease of grinding, but to be specially suitable for machining high-tensile steels, such as are employed in the aero-engine industry. The new material, however, is not supplied as bar stock, but only in the form of finished tool bits, tipped tools, milling-cutter blades and tools of special form. It is claimed that the Grade 80 alloy has a life per grind of six times that of high-speed steel.

ENGINEERING TRAINING AND EDUCATION.

Institute of Marine Engineers.—Examinations for admission to the associate membership and graduate membership of the Institute of Marine Engineers will be held from May 19 to 26, 1941. The Institute's examination for admission to student membership is discontinued, the Council having adopted, instead, the common preliminary examination of the Engineering Joint Examination Board. Two of these examinations will be held in 1941, namely, from April 1 to 5 and from October 7 to 11. The Institute's examinations are held in London and other centres in Great Britain, and particulars of the syllabuses, exemptions allowable, copies of previous examination papers, and the latest dates for application, may be otained by communicating with the Secretary, The Institute of Marine Engineers, 73, Amersham-road, High Wycombe, Bucks.

BOOKS RECEIVED.

Aircraft Identification. Friend or Foe? Part 2. *British and German Troop Carriers and Seaplanes. British Trainers.* London: Temple Press Ltd. [Price 2*s.* net.]

Radio-Frequency Measurements by Bridge and Resonance Methods. By DR. L. HARTSHORN. London: Chapman and Hall, Ltd. [Price 21*s.* net.]

The Microscope. By R. M. ALLEN. London: Chapman and Hall, Ltd. [Price 15*s.* net.]

An Introduction to the Kinetic Theory of Gases. By SIR JAMES JEANS. London: Cambridge University Press. [Price 15*s.* net.]

United States National Bureau of Standards. Circular C427. *Synthetic Rubbers: A Review of Their Composition, Properties and Uses.* By L. A. WOOD. Washington: Superintendent of Documents. [Price 10 cents.]

United States National Bureau of Standards. Building Materials and Structures. Report BMS47. *Structural Properties of Prefabricated Wood-Frame Constructions for Walls, Partitions and Floors, Sponsored by American Houses, Inc.* By H. L. WHITTEMORE and A. H. STANG, with the collaboration of T. R. C. WILSON. Washington: Superintendent of Documents. [Price 10 cents.]

Electricity Applied to Marine Engineering. By W. LAWS. London: The Institute of Marine Engineers, 85-88, The Minories, E.C.3. [Price 5*s.* 6*d.* net.]

The Manchester Association of Engineers. Transactions. Session 1939-40. Edited by T. MAKEMSON and J. BOLTON. Manchester: Offices of the Institution, St. John-street Chambers, Deansgate.

Hydraulic Measurements. A Manual for Engineers. By PROFESSOR HERBERT ADDISON. London: Chapman and Hall, Ltd. [Price 21*s.* net.]

United States Bureau of Mines. Technical Paper No. 610. *Correlation Index to Aid in Interpreting Crude-Oil Analyses.* By H. M. SMITH. Washington: Superintendent of Documents. [Price 10 cents.]

Electrical Measurements in Principle and Practice. By H. C. TURNER and E. H. W. BANNER. London: Chapman and Hall, Ltd. [Price 7*s.* 6*d.* net.]

United States Bureau of Mines. Economic Paper No. 20. *Petroleum Statistics, 1935-1938.* By G. R. HOPKINS. [Price 10 cents.] Economic Paper No. 21. *Trends and Seasonal Variations in Factors Influencing Domestic Motor-Fuel Demand.* By H. A. BREAKEY. [Price 10 cents.] Washington: Superintendent of Documents.

United States Bureau of Mines. Bulletin No. 423. *Mechanical Shoveling in Underground Metal Mines.* By MCHENRY MOSIER and J. H. STEINMESCH. [Price 25 cents.] Bulletin No. 430. *Coal-Mine Accidents in the United States, 1937.* By W. W. ADAMS, L. E. GEYER and M. G. PARRY. [Price 15 cents.] Washington: Superintendent of Documents.

The Mechanical Testing of Metals and Alloys. The Theory and Practice of Standardised Mechanical Testing. By P. F. FOSTER. Second edition. London: Sir Isaac Pitman and Sons, Ltd. [Price 6*s.* net.]

Applied Chemistry for Engineers. By Dr. E. S. GYNGELL. London: Edward Arnold and Company. [Price 15*s.* net.]

INSTITUTION OF AUTOMOBILE ENGINEERS.—In view of the prevailing conditions it has been decided that the opening meeting of the session of the Institution of Automobile Engineers shall be deferred and due notice will be given when the revised date is settled. Meanwhile, Mr. M. Melhuish will read a paper, entitled "Bearing Metals and their Suitability for Modern Requirements," before the Coventry, Manchester, and Birmingham provincial centres of the Institution. The meeting at Coventry will take place at 7.0 p.m. on Tuesday, October 8, at the King's Head Hotel; that at Manchester, at 7.30 p.m. on Wednesday, October 9, at the Engineers' Club, Albert-square; and that at Birmingham, at 7.0 p.m. on Tuesday, October 22, at the James Watt Memorial Hall, York House, Great Charles-street.

PERSONAL.

MR. B. J. BURRIDGE has been appointed assistant chief engineer of the Telephone Manufacturing Company, Limited, Martell-road, W. Dulwich, London, S.E.21. He is acting as chief engineer of one of the firm's works.

The Minister of Supply has appointed MR. GEORGE CLEMENT JENKS, J.P., M.I.Mech.E., chairman and managing director of the British Tool and Engineering Company, Limited, Wolverhampton, to be Director of Hand Tools in the Department of the Director-General of Equipment and Stores.

MR. J. INNES, B.Sc., M.I.E.E., succeeded to the position of Director of Telecommunications on the retirement of MR. F. W. PHILLIPS, C.M.G., on September 6. Mr. Innes has also been appointed a member of the Post Office Board.

MESSRS. THE STAVELEY COAL AND IRON COMPANY, LIMITED, near Chesterfield, inform us that the address of their Glasgow office is now Kennyhill Goods Depot, L.M.S. Railway, Cumbernauld-road, Glasgow (Telephone: Provanmill 4488). MR. H. GILLESPIE is in charge, assisted by MR. J. BALL. The services of MR. GEORGE H. HUTCHISON, who has acted as the firm's agent for many years, are being retained in a consultative capacity.

MESSRS. THE BRTISH ALUMINIUM COMPANY, LIMITED, inform us that the address of their temporary head office, which they are to occupy from September 30, is Oakley Manor, Belle Vue, Shrewsbury, Shropshire, and not Belle Vue-road, as stated in an earlier letter which we quoted in this column last week (page 228, *ante*).

MR. A. J. PALMER has been appointed a director of Messrs. Vickers-Armstrongs Limited, and of the Thames Ammunition Works, Limited.

MR. A. E. REDDELL, who was appointed works superintendent to The Whitehead Torpedo Company, Limited, in 1934, and a special director in 1938, has now been made acting general manager of the firm.

MR. H. H. BURTON, chief metallurgist and a special director of the English Steel Corporation, Limited, Sheffield, has been elected a director of the Darlington Forge, Limited, Darlington.

TENDERS.

WE have received from the Department of Overseas Trade, Great George-street, London, S.W.1, particulars of the undermentioned tenders, the closing dates of which are as stated. Details may be obtained on application to the Department at the above address, quoting the reference numbers given.

Paint, lead-less, white, in paste form. South African Railways and Harbours, Johannesburg; October 18. (T. 21,797/40.)

Dry Red and White Lead. South African Railways and Harbours, Johannesburg; October 25. (T. 21,798/40.)

Water-Pumping Units, centrifugal, electric-motor-driven, and electrical equipment, at Municipal Waterworks on the Vaal River, at Riverton. City of Kimberley, South Africa; October 31. (T.Y. 21,800/40.)

Transformers, static, three 300-kVA and five 500-kVA, ratio 6,600/400, windings delta-star, O.N.-type for outdoor service, with off-load tap-changing equipment. Electricity Department, Municipality of Singapore, Straits Settlements, or the Municipality's inspecting engineers, Messrs. Peirce and Williams, 1, Victoria-street, London, S.W.1; November 11. (T. 21,826/40.)

AIR-CONDITIONED COACHES ON AMERICAN RAILWAYS.—According to statistics published by the Association of American Railroads, the main-line companies and the Pullman Company owned 11,986 air-conditioned passenger coaches on July 1. This total constituted an increase of 635 compared with July 1, 1939, and of 271 compared with January 1, 1940.

CANADIAN NEWSPRINT-PAPER INDUSTRY.—The newsprint-paper industry of Canada has shown a marked expansion in the first four months of the present year. It is stated in the current issue of *The Paper-Maker* that 1,003,080 tons of newsprint paper were produced in the period January to April, 1940, as compared with 850,500 tons in the corresponding part of last year. For April, 1940, alone, production rose by 22 per cent. as compared with last year, namely, from 220,240 tons in April, 1939, to 268,950 tons in April of this year. Eighty per cent. of the exports of the paper in April, 1940, went to the United States, while Australia, Argentina and New Zealand ranked second, third and fourth in order of tonnage imported. The United Kingdom purchases of Canadian newsprint paper in April of this year amounted to a total of 12,568,000 lb.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—Evidence of the effects of the loss of export trade on the coalfield were again apparent last week. No surprise was therefore occasioned on the market by the announcement in Parliament by the Minister of Labour, Mr. Ernest Bevin, that it was proposed to call up for military service a number of miners of the lower age groups. Among other steps which were to be taken to meet the changed position of the industry, he said, were a cessation of the return of ex-miners back to the pits and the release of unemployed miners from the restriction placed upon them preventing them from taking up other employment. Home demand was fairly brisk on the market throughout the week and heavy deliveries continued to be made to this destination. Foreign business, however, remained small. Collieries were therefore compelled to rely upon the inland trade to enable them to maintain production at recent levels and although, as a general rule, supplies were not excessive, there was no lack of coal, but sellers were not pressing and the tone was very steady. Best large sorts were moving off fairly satisfactorily while the popular sized descriptions remained difficult to secure. Bituminous smalls were in demand but scarce; dry smalls, on the other hand, were plentifully offering and dull. Cokes were busy but patent fuel remained quiet.

The Iron and Steel Trade.—Activities were well maintained in the iron and steel and allied trades of South Wales and Monmouthshire last week. The demand for the various finished products was well sustained and, with order books well filled ahead, the works were assured of the maintenance of present conditions for some time to come.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—In the Scottish steel trade there has been little or no change during the week and all plant is running at full capacity. Buyers of steel for general purposes find it difficult to secure material unless they have obtained a permit, as the requirements of firms engaged on Government contracts absorb the bulk of the current output. The production of high-grade steel is a special feature at the present time and the tonnage going through has been increasing steadily during recent months. Export business is small at present but numerous inquiries are coming to hand. The demand for light steel is quite as great as that for the heavier grades, and the makers of black and galvanised sheets have very full order books; in many cases, buyers are pressing for deliveries. The supply of raw materials is ample for requirements, owing to the arrangements made by the committee dealing with imports. Prices are unchanged and are as follows:—Boiler plates, 15*l.* per ton; ship plates, 14*l.* 3*s.* per ton; sections, 13*l.* 13*s.* per ton; medium plates, rolled in sheet mills, ¼ in. and thicker, 18*l.* 7*s.* 6*d.* per ton; mild-steel black sheets, No. 21-24 gauge, close annealed, 19*l.* 7*s.* 6*d.* per ton; galvanised sheets, plain, No. 21-24 gauge, 23*l.* 2*s.* 6*d.* per ton, and corrugated, No. 24 gauge, 22*l.* 12*s.* 6*d.* per ton.

Malleable-Iron Trade.—There has been a good demand for malleable-iron during the past week and the West of Scotland makers are comfortably off for business. For re-rolled steel bars the demand is of an urgent nature and makers are doing their best to maintain deliveries. The recent output has been so heavy that stocks of semi-manufactured material have been getting low, but fresh supplies have been received and the outlook is satisfactory. The following are the market quotations:—Crown bars, 15*l.* 2*s.* 6*d.* per ton; best iron, 15*l.* per ton; No. 3 bars, 13*l.* 7*s.* 6*d.* per ton; No. 4 bars, 13*l.* 12*s.* 6*d.* per ton; re-rolled steel bars, tested, 15*l.* 11*s.* 6*d.* per ton, and untested, 15*l.* 8*s.* 6*d.* per ton; angles and tees, 4 in. and under, tested, 15*l.* 1*s.* 6*d.* per ton, and untested, 14*l.* 18*s.* 6*d.* per ton.

Scottish Pig-Iron Trade.—In the Scottish pig-iron trade all the furnaces in blast are being operated at full capacity and as the demand is heavy there is no accumulation of stock. Deliveries to steelmakers account for a very large tonnage but the position with regard to foundry iron has not changed and all demands are easily met. The supply of iron-ore is quite satisfactory at the present time and good stocks are held.

CORNISH CHINA-CLAY INDUSTRY.—The shipment of china clay and stone from Cornwall during July, much of it from the port of Fowey, totalled 44,879 tons, compared with 40,556 tons in June and 64,340 tons in July, 1939. The increased shipment of 4,000 tons in July, as compared with June, is gratifying in view of the fact that many of the china-clay markets abroad are practically closed.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—Ordinary transactions in iron and steel are still on a limited scale, but the aggregate tonnage output remains at an exceptionally high level and slightly increased parcels of certain commodities are obtainable for the usual industrial purposes. Strict adherence to the regulations of the control of distribution scheme continues and, under existing conditions, the scheme is proving satisfactory. The more urgent needs of firms directly engaged in work of national importance are regularly met. A gratifying feature of the present position is the ability to continue export trade. Licences for shipments overseas are granted as soon as tonnage can be spared for loading and the dispatch of commodities to distant destinations promises to be augmented.

Cleveland Iron Trade.—The production of Cleveland pig is irregular and light, and second hands are handling only very moderate parcels. Users of foundry iron, however, still receive ample supplies from elsewhere, chiefly from the Midlands, and the meagre tonnage of local brands obtainable is causing little inconvenience. Firms requiring Scottish iron for particular purposes continue to acquire adequate parcels. Under such conditions, efforts to overcome the various obstacles to the enlargement of Tees-side makes are not regarded as essential and the prospects of a movement towards the resumption of a continuous output are remote. Market values of Cleveland pig are ruled by No. 3 quality at 120*s.*, delivered to buyers in the Middlesbrough zone.

Hematite.—The heavy production of East Coast hematite is absorbed as soon as it becomes available and, as makers are experiencing difficulty in keeping pace with the expanding demand, American iron is being imported. Little saleable local hematite is available though the make has reached the full capacity of the furnaces in operation. Merchants are receiving small quantities occasionally, but their holdings are not sufficient fully to discharge their delivery obligations to old customers. Deliveries due to home users who have to purchase hematite are substantial, but most of the production continues to be taken up by the makers' own consuming departments. Quotations are based on No. 1 grade of hematite at 131*s.*, delivered to North of England customers.

Basic Iron.—The whole of the basic-iron output is appropriated for use at steelworks owned by basic-iron makers and, with no tonnage on the market, the quotation of 113*s.* is nominal.

Foreign Ore.—The unloadings of foreign ore are sufficient to keep the consumers' stocks at an exceptionally high level.

Blast-Furnace Coke.—Transactions in Durham blast-furnace coke are very few. Sellers have substantial tonnages on hand, but have sold as extensively as they consider advisable and local users are bought well ahead. The recognised price of good medium qualities is 33*s.* 5*d.* at the ovens.

Manufactured Iron and Steel.—Home-made and imported semi-finished iron and steel deliveries are ample for the needs of re-rollers and all the mills are turning out maximum tonnages. Sheetmakers are operating their plant at full capacity to comply with customers' requirements and have contracts to execute that will keep them busily employed for some months. Heavy-steel producing plant must be kept running at full capacity well beyond the end of the year to cope with the delivery demands. Soft-steel billets are quoted at 10*l.* 10*s.* to 10*l.* 15*s.*; hard billets at 11*l.* 17*s.* 6*d.*; joists and angles at 13*l.* 13*s.*; heavy plates at 14*l.* 3*s.*; and boiler plates at 15*l.* 0*s.* 6*d.*

Scrap.—Iron and steel scrap is now quite plentiful and stocks of most descriptions are satisfactory.

FIRE PRECAUTIONS IN FACTORIES.—The Minister of Home Security has made an Order under the Defence Regulations (cited as The Fire Watchers Order, 1940), providing that a fire watcher shall be present at all times in all premises in which more than 30 persons work. This Order applies in addition to any premises, whether or not more than 30 persons work therein, the whole or any part of which is used as a warehouse of greater capacity than 50,000 cub. ft., and any saw mill or timber yard containing more than 50,000 cub. ft. of timber. The Order does not apply to a warehouse when it is empty or to premises which form part of any mine or quarry. During the period in which a hostile attack is in progress in the vicinity, or an air-raid warning is in operation, the person who has undertaken to act as fire watcher must be in readiness to attack an outbreak of fire and summon assistance, and to use such fire-fighting appliances as may be available. The person, responsible under the Order for seeing that it is carried out, is the occupier of the premises. Any two or more occupiers of different parts of the same premises may arrange to provide one fire watcher for the whole building.

NOTICE OF MEETING.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INSTITUTION OF STRUCTURAL ENGINEERS.—*Yorkshire Branch:* Saturday, September 28, 2.30 p.m., The Hotel Metropole, Leeds. Chairman's Address: "The Results of Recent Research on the Effects Upon Buildings of High Explosive and Incendiary Bombs," by Dr. R. H. Evans.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Though production in this area is mainly connected with the war effort, an increasing amount of commercial business is being done. Numerous orders have been placed in the last few months for heavy machinery and engineering products. Though the volume of business is principally on home account, export sales show a tendency to rise. Steelworks' and ironworks' equipment is a progressive section. Firms specialising in the manufacture of rolling mills, forges, presses, and all types of engineering plant are particularly busy. Heavy forgings and castings, hollow-forged boiler drums, and vessels capable of withstanding high pressures and temperatures are in demand. The demand for railway rolling stock is developing satisfactorily, orders having been booked from abroad, particularly from South Africa, India, and New Zealand, for wheels, axles, springs, tyres, and buffers. Grinding and crushing plant is in request, and cement and concrete mixers are in good demand. The market in excavators is also active, and the call for mining equipment is stronger than for two or three years. Unprecedented outputs are being accounted for by makers of all types of high-efficiency steels. Machinery and tool makers are consuming record tonnages of steels capable of withstanding excessive strain and wear. Further headway is reported by tool-makers, and large increases in output are reported by many works. Recent efforts to develop export sales have been successful, and increased shipments of agricultural tools, files, twist drills, and small tools are reported. Numerous orders are circulating for raw and semi-finished materials. The scrap position is better than for many months past.

South Yorkshire Coal Trade.—The coal market generally shows little change; both supply and demand have been maintained. Industrial concerns are taking heavy supplies, and many are accumulating stocks to cover a possible winter shortage. The house coal market is active, and householders are having little difficulty in obtaining adequate supplies. A strong demand persists for foundry and furnace cokes.

SLAB-REHEATING FURNACE IN AUSTRALIAN STEELWORKS.—A new reheating furnace has recently been installed near the plate and bar-rolling mill at the Newcastle Works, New South Wales, of Messrs. The Broken Hill Proprietary Company, Limited. The fuel used is a preheated mixture of blast-furnace and coke-oven gases and air, and the furnace has a capacity of 45 tons of slabs per hour. The furnace comprises a preheating zone, a heating zone and a soaking zone. In common with all modern furnaces of this type, temperature-recording and fuel-control equipment is provided.

COPPER-SMELTING WORKS IN THE URALS.—The Central Urals Copper-Smelting Works, the largest of its kind in the U.S.S.R., and situated in the heart of the Urals mining area, at Revda, 25 miles from Sverdlovsk, was recently put into operation. It is stated in the current issue of *Chemistry and Industry* that the capacity of the new plant is 1½ times the entire output of copper in Russia in 1913. Copper ore will be supplied by the Degtyarsk pyrites deposits and the reverberatory furnaces, one of which is 105 ft. long by 26 ft. 3 in. wide, will be heated by means of pulverised fuel. It is claimed that the equipment makes it possible to extract as much as 95 per cent. of the metal from the ore.

METHOD OF MEASURING CORROSIVENESS.—In a paper recently submitted to the American Society for Testing Materials, Mr. J. H. Walker describes an apparatus for measuring the corrosiveness of water and condensates in steam-heating systems. The apparatus consists of three helical coils, made of Bessemer-steel wire, 0·05 in. in diameter, mounted in a frame which can be introduced into the pipes of the system. After 28 days' exposure, the frame is taken out of the system, the products of corrosion removed by treatment with an acetic-acid solution containing an inhibitor, and the loss in weight determined. The average loss in weight of the three coils, which are of the same dimensions, is taken as an indication of the corrosiveness of the water or condensate.

SIDE DRAGLINE ATTACHMENT FOR EXCAVATORS.

CONSTRUCTED BY MESSRS. PRIESTMAN BROTHERS, LIMITED, HULL.

(*For Description, see Page 247.*)

FIG. 4. CLEANING DRAIN ON OPEN GROUND.

FIG. 5. CLEANING DRAIN ALONG HEDGE.

THE ADHESION OF WHITE-METAL LININGS IN BEARINGS.

THE importance of securing good adhesion between the white-metal lining and the supporting shell in the bearings of internal-combustion and other engines is obvious and methods of ensuring this must be based on definite knowledge of the properties of the two materials concerned. The matter, for some years past, has been the subject of systematic study on the part of the research staff of the International Tin Research and Development Council, and two useful reports on this subject have recently been issued. The first essential for good adhesion is that the shell must be given a complete and continuous coating of tin before the white-metal lining is poured. It is pointed out in this connection, however, that cast iron and certain alloy steels are difficult to tin, steels containing more than 0·25 per cent. of nickel or more than 0·6 per cent. of manganese being particularly troublesome. The most dependable method in such difficult cases, it has been found, is to copper-plate the shell before tinning. The shell should be in the freshly-turned condition.

The shell is first de-greased; as a preliminary operation, it may be swabbed with a suitable solvent to remove most of the oil. The remaining oil may then be removed in a trichlorethylene-vapour bath or by boiling for ten to fifteen minutes in an alkaline bath. Cathodic degreasing, however, is considered to be the most thorough method. The shell is immersed in a solution of sodium carbonate and trisodium phosphate contained in an iron pot, which is connected to the positive terminal of a 12-volt accumulator, shell being connected to the negative pole. The rapid evolution of hydrogen disrupts and dislodges the film of grease on the shell.

The degreased shell is then subjected to anodic etching to provide a reactive surface. In this operation, the shell is joined by a stout cable to the positive pole of a source of current at 12 volts. The other pole is connected to a lead-lined tank containing 50 per cent. cold sulphuric acid (specific gravity 1·40). The shell is lowered into the acid and a current of very high density is passed. At first the surface of the shell blackens, but after a quarter of a minute this changes to a silvery grey and oxygen is evolved freely. When this occurs the etch is adequate and the shell is removed, rinsed and transferred to a cyanide copper-plating bath of the standard type. It is recommended that a layer of copper from two to three thousandths of an inch in thickness be deposited. The copper-plated shell is now ready for tinning; it is brushed with a flux and immersed for a few seconds in a tinning bath maintained at a temperature of from 240 deg. to 245 deg. C. (464 deg. to 482 deg. F.). Copper tins very readily at this temperature, but it is emphasised that the range mentioned should not be exceeded on account of the risk of dissolving off the copper coating and exposing the non-tinnable steel or cast iron beneath. The tinned shell can now receive the white-metal lining which is poured in the usual way.

While copper, bronze, brass or mild-steel shells may be tinned relatively easily, it is pointed out that the degreasing treatment should be conducted in as thorough a manner as with cast iron or alloy-steel shells. They are then pickled to provide a reactive surface. The temperature of the tinning bath, in the case of the copper and copper-alloy shells, should be at a maximum of 260 deg. C., in order to avoid the formation of excessive amounts of inter-metallic alloy. The time of immersion should be up to two minutes. For mild-steel shells, the tin bath should be at a temperature of 400 deg. C.

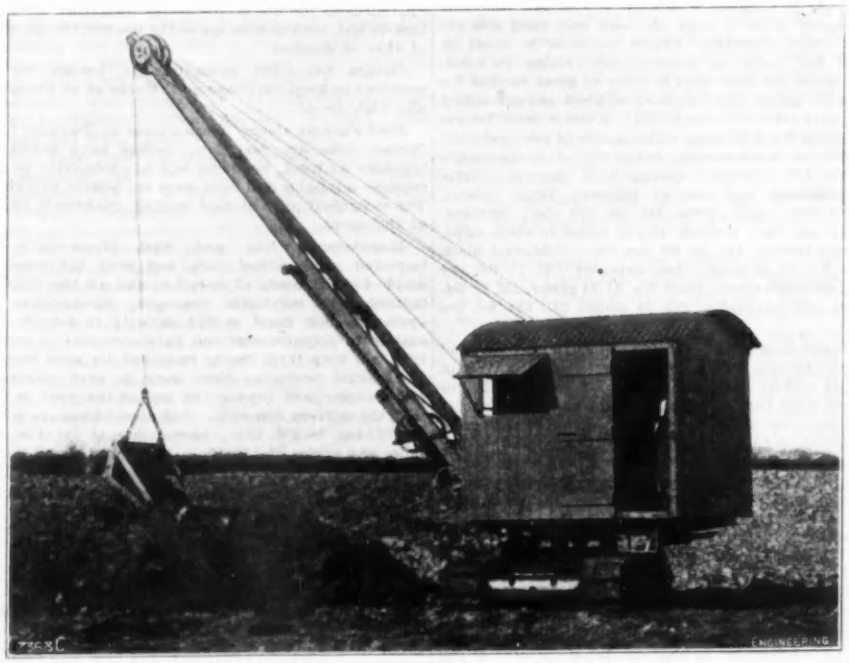


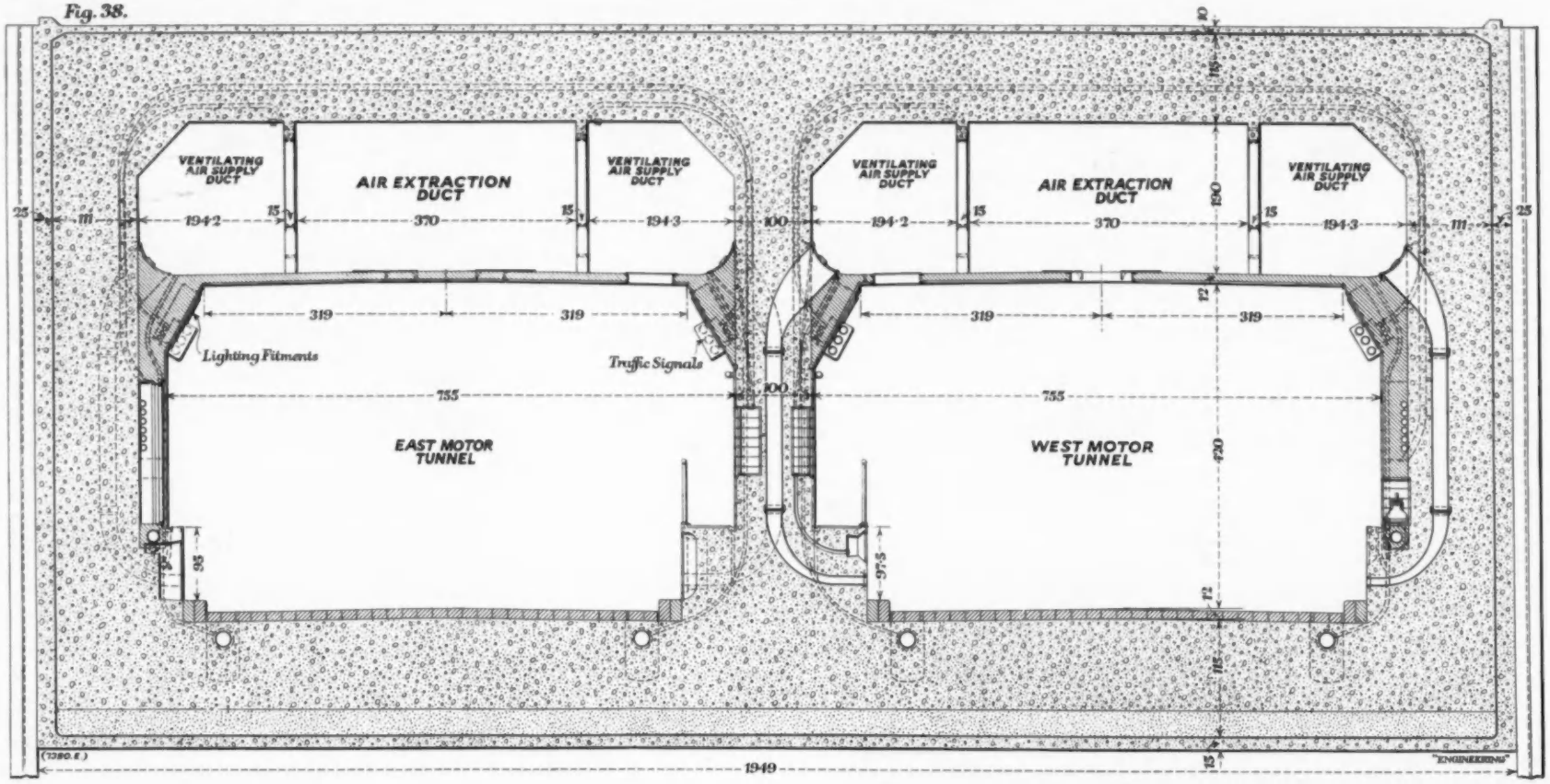
FIG. 6. USE OF SCRAPER PLATE FOR SPREADING SOIL.

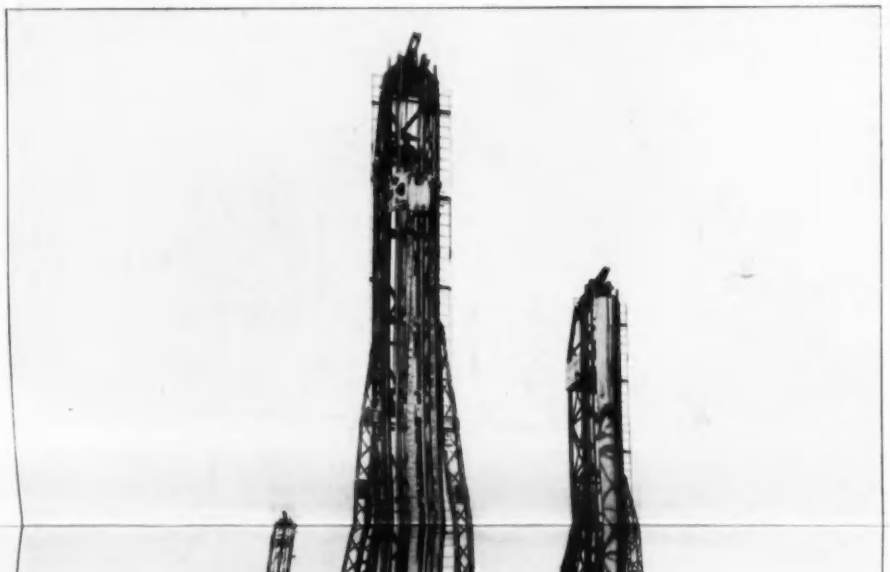
WITHDRAWAL OF HARWICH FERRY SERVICE.—The hourly ferry service run between Harwich and Felixstowe Dock maintained by the London and North Eastern Railway has now been withdrawn.

ROAD TUNNEL UNDER THE RIVER MAAS, ROTTERDAM.

(*For Description see Page* 244.)

Fig. 38.





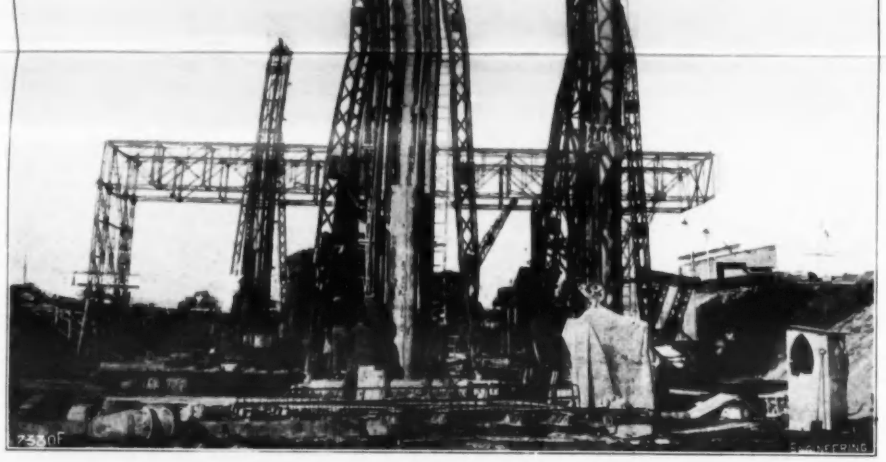


FIG. 39. DRIVING PILES FOR LAND TUNNEL ON THE LEFT BANK.

FIG. 40. APPLYING ASPHALT LAYER IN LAND TUNNEL TRENCH.

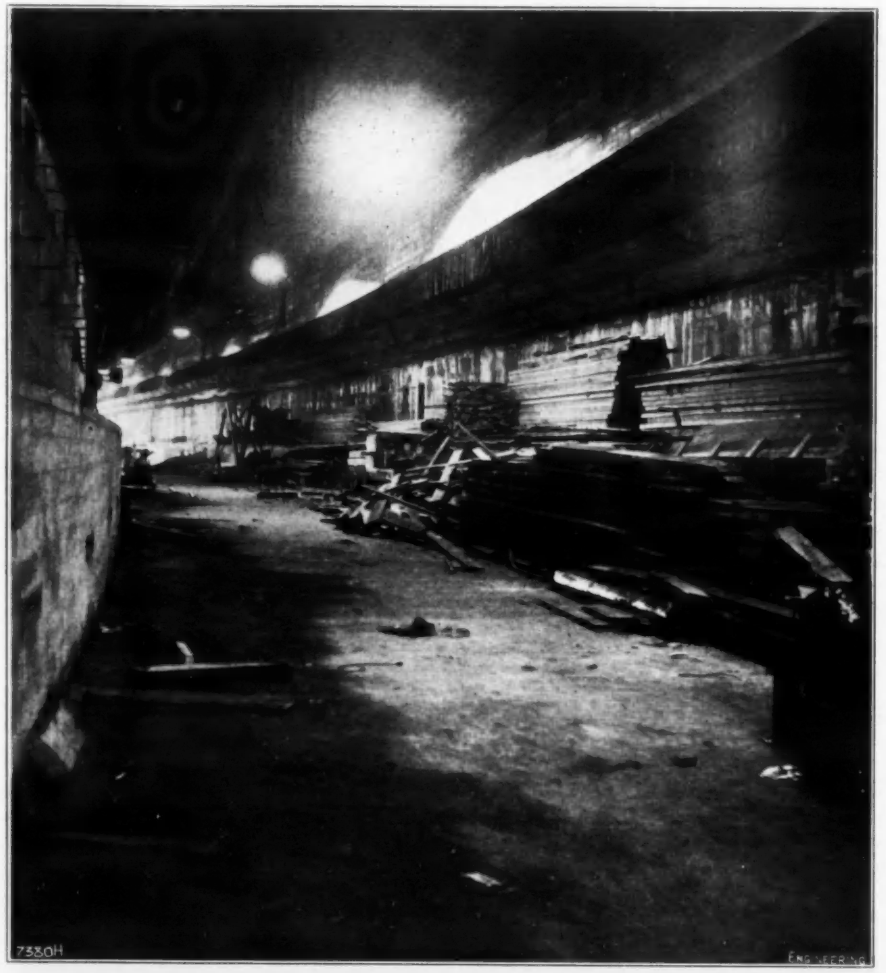


FIG. 41. INTERIOR OF LAND TUNNEL NEARING COMPLETION.

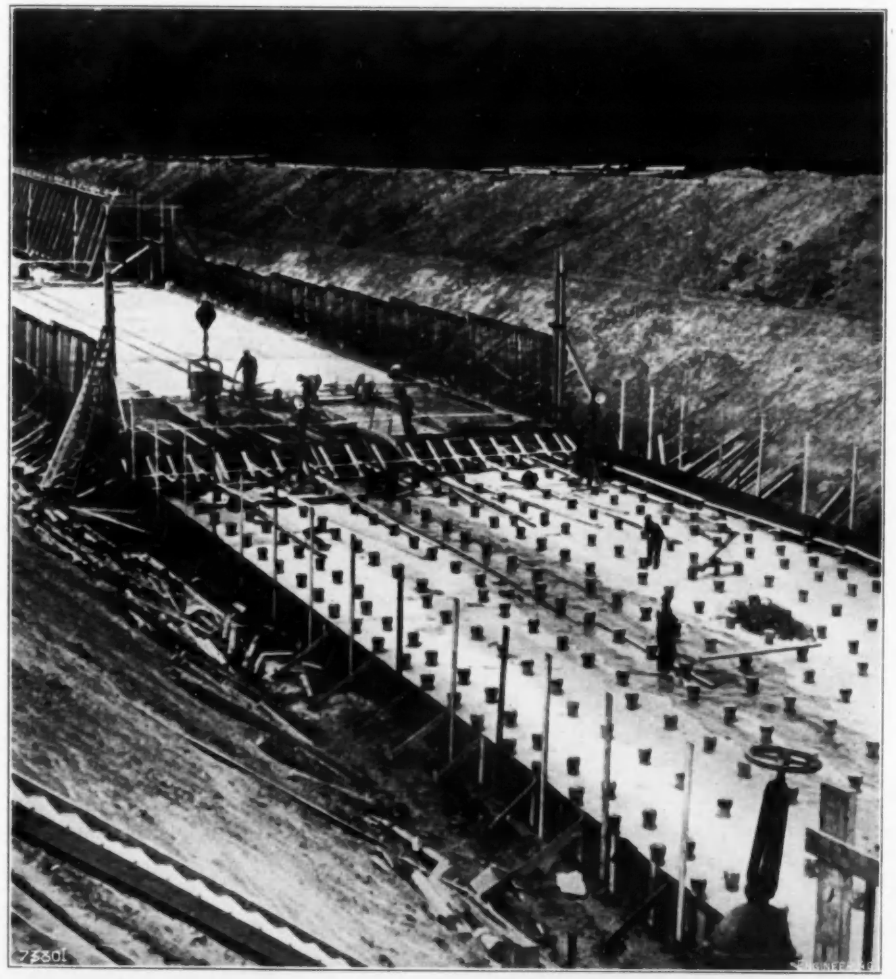


FIG. 42. CONCRETE BEING PLACED ON SECTION OF APPROACH RAMP.

UNIV. OF MICH.

ENGINEERING.

Offices for Publication and Advertisements, 35 & 36, Bedford Street, Strand, London, W.C.2.

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TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be delivered not later than first post on Wednesday. Alterations to standing advertisements must be received at least 10 days previous to the day of publication. Passed proofs must be in our hands by Saturday morning, otherwise they will be taken as correct. The Proprietors will not hold themselves responsible for blocks left in their possession for more than two years.

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TEMPORARY ADDRESS.

For the duration of hostilities, the Editorial and Publishing business of this Journal is being conducted from 18 and 20, Compton Road, Hayes, Middlesex. The Telephone Number of the Editorial Department is Hayes 1730, and that of the Publishing Department, Hayes 1723. The Bedford Street Offices are open on Fridays only, between 10 a.m. and 5 p.m., for the distribution of the current issue and for retail sales.

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One Two-Page Plate.—ROAD TUNNEL UNDER THE RIVER MAAS, ROTTERDAM.

ENGINEERING

FRIDAY, SEPTEMBER 27, 1940.

VOL. 150. No. 3898.

WAR CONDITIONS AND CIVIC DEVELOPMENT.

THE motives which have influenced the location of modern communities may appear, at first sight, to be more diverse than those operating in the dim past, but actually the ruling factors are almost unaffected by the passage of the centuries. Food and water, a dwelling place of some sort, and a reasonable measure of security against weather and the assault of enemies—these desiderata, common to man, beast, bird and even insect, still condition the practicability of successful colonisation, whatever other inducement may initiate the movement. Applied science has facilitated the establishment of communities in places where otherwise life could have been sustained only with difficulty, if at all—for example, in the Kalgoorlie goldfields, which depended for water upon supplies pumped for some hundreds of miles; but in the balance the water was more important than the gold, as it has been since the beginning of communal life.

On September 13 was celebrated the fiftieth anniversary of the foundation of Southern Rhodesia by the pioneer column which had trekked from Kimberley to take over and develop the territory for which mining concessions had been granted to Cecil Rhodes by Lobengula, the Matabele chieftain. On September 29, as related by Mr. W. J. Jarvis, city engineer of Salisbury, in a paper, extracts from which are given on page 257 of this issue, a beginning was made on the construction of the waterworks. The intervening fortnight had been occupied with the building of a fort, which the pioneers had completed on the previous day; and it is significant of the unchanging essentials of colonisation that the assurance of a proper water supply was regarded as a necessary preliminary to all other activities, even though the fort was erected in close proximity to a river. It was only on the following day, September 30, 1890, that mining law was provisionally proclaimed, and prospecting licences were issued to enable the individual members of the column to proceed about the business which had brought them into what is now Southern Rhodesia.

There could hardly be a better example of the processes which must have led to the establishment in their present situations of so many capital cities, the origins of which go far back into the history of mankind. It was no chance that located London and Paris and Rome, not to mention Sheffield and Newcastle, and many another industrial centre, now grown so far beyond their original boundaries, and often so changed in character, that it is difficult to realise the primitive conditions of their early days. There were, of course, many other contributory causes, prominent among them the military considerations which governed communal life until the general spread of a more ordered existence. That state has obtained for so long in these islands that a tendency had grown up, prior to 1914, to regard it as something settled and immutable, in spite of the wars that had periodically afflicted other European nations. The four years of war from 1914 to 1918, while they may have shaken this belief to some extent at the time, did not eradicate it; indeed, the conviction that a war of such a prolonged and costly character could not be quickly followed by another seems to have encouraged both civic and industrial expansion in directions which it could hardly have taken if the lessons of history had been properly assimilated.

It is easy to see now that a thoughtful reading of the signs of the times should have diverted to the western coasts of Britain much of the recent industrial development that has been so marked on the eastern and south-eastern seaboards, and that there would have resulted the added advantage, in the light of aerial attacks, that a much smaller proportion of the population would then have been concentrated in the vulnerable Home Counties. The fact remains that the signs were not read aright, by the majority of those in a position to make their voices heard; and commercial considerations once again monopolised public attention. The development of west-coast harbours would have involved long and heavy rail haulage, at considerable added expense, to the chief centres of population; and although several attempts were made to encourage import trade through western ports, notably those of South Wales and the Bristol Channel, the financial advantage of carrying incoming goods as far as possible by sea continued to encourage the extension of facilities on the south and east coasts. In a country deliberately organised for war and run on financial lines so far divorced from sound commercial principles as Germany has been under the Nazi regime, the provision of extensive port facilities which would be required only in time of war might have been practicable, but such a provision would have stood no chance of approval in this country if any railway company or harbour authority had had the temerity to propose it.

The improbability that any large centres of population will arise in any part of the British Isles not at present industrialised makes the study of the location and layout of new cities largely an academic question so far as these islands are concerned, but it is still possible that such communities may develop in parts of the Empire at present peopled only sparsely, if at all; and the experiences that Europe in general has undergone in the past twelve months suggest that the military considerations, which have gradually lapsed into the background, should once again be given due weight in planning for future mass movements of population, if no effective means can be found to ensure that warfare shall be abolished. Past history offers little hope of such a consummation. The unpalatable fact still remains that, the more highly organised a nation becomes, the more does it become possible for a force of determined and unscrupulous adventurers to seize possession of the machinery of organisation, as the various "fifth columns" have done in one country after another that has fallen under German domination.

The most effective means of countering such moves lies in the field of political organisation and hardly comes at any point within that of practical engineering; but, in the wholesale reconstruction of cities and towns that must be undertaken throughout Europe, and perhaps even farther afield, there will be ample scope for the employment of all the engineering ingenuity and skill that the

stress of war has brought to such a high pitch, in the endeavour to guard against the military disabilities that are inherent in the haphazard civic development of the past fifty or hundred years. The vulnerable character of most public utility services has been demonstrated wherever large-scale air attacks have been launched against closely built-up areas; in Germany itself, formerly so obsessed with the idea of centralised organisation, it may be supposed that the advantages of decentralisation, so far as actual plant is concerned, are becoming more and more apparent. London has been relatively fortunate, for although, as officially announced, there has been some local interruption of transport and of water, gas and electricity supplies, the result has been no more than temporary inconvenience, regarded against the background of a major war. The cost of relaying such a network of pipes and main cables as now exists in London makes such a precaution impracticable in this particular instance, but there is no doubt that some, at least, of these mains could have been laid initially in better-protected situations; and, where extensive rebuilding of property has now been rendered necessary, the possibility of replacing the various mains under the buildings instead of under the roadways—of course, with due provision for access—should not be overlooked.

In the reconstruction of the buildings themselves, it will be quite possible, and should be made compulsory, to ensure that basement floors are made sufficiently strong to serve as shelters without any additional strengthening. In the larger office buildings, this requirement is virtually met by the scantlings necessary to support the building overhead, and it is only in the case of the smaller shop property that cellars, normally provided for storage purposes only, are likely to be so lightly covered as to be unable to carry the weight of the overhead structure in case of its collapse. All that would be needed to render such cellars available as emergency shelters would be an amendment to the building by-laws to ensure safety against failure of the floor above, and the provision of means of escape.

Whether domestic architecture is likely to be affected permanently by defensive considerations is a question, the probable answer to which is less easy to predict, and one which is likely to hinge more upon matters of finance. Obviously, it would be desirable that every private house should possess some kind of shelter accommodation, and in the larger types, in which the individual fancies of the owner may be less hampered in their realisation by questions of cost, it is to be expected that some such provisions will be made. Whether it can be generally extended to the smaller types of property is bound to depend largely upon the attitude of local authorities. Where builders have the foresight to make such provision, it seems inevitable that they will advertise the fact as an added attraction of the property and will seek to increase their price accordingly. In that event, the extra security afforded will represent an enhancement of the value of the property and is likely to involve a higher assessment for rating purposes, unless, when the present emergency legislation is repealed, steps are taken to make permanent the instruction which, at present, debars local authorities from increasing assessments on account of shelters.

Commonsense would suggest the enactment of a comprehensive statute forbidding any such move; indeed, a case could be well made out for a reduction of assessments where a property owner has had the good sense to provide reasonably efficient protection, on the ground that, the more general such a provision can be made, the less is likely to be the demand upon the rescue, casualty and other emergency services, the nucleus of which it will probably continue to be the responsibility of local authorities to maintain. It is unlikely, to say the least, that a move for automatic reduction of assessments in such an event would meet with any success, but there is justification for hoping that the present policy may be stabilised after the war in view of its obvious desirability. Encouragement to fit window shutters, to provide external water taps for emergency fire protection, and to place meters, stopcocks and switches in positions of security are other matters to which attention might be directed.

ELECTRICITY SUPPLY IN SOUTH AFRICA.

THE advantages of continuity of policy, and even of management, over a wide area are now generally admitted in principle when it comes to dealing with electricity supply on a large scale, though, in practice, insuperable difficulties sometimes prevent their full realisation. Such difficulties, however, were not present when the Electricity Supply Commission of South Africa was established shortly after the last war; and the seventeenth annual report, which has recently come to hand, indicates that progress is being maintained at a satisfactory rate. This progress has naturally been considerably assisted by the existence of the main-line railway load in Natal and by the use of the same form of traction in the vicinity of Cape Town and Pretoria, but considerable energy has also been shown in developing the domestic load both in the larger towns and in the more rural districts. Considering the character of the country, the advance under the latter heading has, indeed, been striking and reflects great credit on all concerned.

During the year ended December 31, 1939, the total output from the six main and three stand-by generating stations was 3,761,808,345 kWh. This represents an increase of 18·5 per cent. over the output of the previous year and constitutes a record in the history of the body. The sales of energy amounted to 3,573,696,440 kWh, this figure exceeding the three thousand million mark for the first time and representing an increase of 19·7 per cent. In fact, the war seems to have had little effect on the functions of this important body, though it is noted that special precautions have been taken to preserve the continuity of supply. The generating capacity of the system was increased by 171,926 kW in 1939, bringing the capacity installed or on order at December 31, 1939, up to 954,156 kW. In particular, the Klip generating station was brought almost to completion and the construction of the Vaal station was commenced.

Dealing with the railway load, the report points out that overseas conditions led to a delay in the delivery of the two double-unit mercury rectifier plants for the Rossburgh-Hillcrest section of the Natal main railway line. It will not, therefore, be possible to operate this section electrically until towards the end of next year. Early in 1940, the Railway Administration requested the Commission to provide five new traction substations on the Reef to cope with the rapidly increasing traffic requirements. The mineral line linking Canada Junction with Jupiter through the southern suburbs of Johannesburg was partially converted to electric traction early in the present year. The supply to Pretoria and Pinedene substations on the Germiston-Pretoria electrified section was duplicated by making a connection to the lines of the Victoria Falls and Transvaal Power Company at Olifantsfontein. The total mileage of electrified railway lines in the Union of South Africa is now 605 route miles, equivalent to 1,232 miles of single track.

There has been further progress in the Commission's policy of making electricity available to inhabitants of rural areas wherever possible. As reported last year, a scheme for supplying farms contiguous to the electrified railway system in Natal from an 11-kV power line mounted on the track structures is being carried out, though it is admitted that the work may be delayed by the war. Actually, as will be seen from the more detailed information given below, there have been considerable extensions to the Commission's systems, notably in the south-west of Natal and in the Cape Western Province. The latter area may now be regarded as the most intensively electrified rural area in South Africa. The total number of towns and villages supplied with electricity at December 31, 1939, was 95, the number of farms connected being 398. These figures show an increase of 14 and 43, respectively. An increase not only in the total sales of electricity for domestic consumption, but also in the consumption per consumer, took place during the year under review. Actually the figure in 1939 was 13,990,173 kWh, compared with 10,520,028 kWh in 1938, while the annual consumption per consumer increased from 1,484 kWh to 1,598 kWh. In view of the fact that many of these consumers, who now total 8,756, live in small and often isolated rural communities, this increase is regarded as satisfactory. An increase of over 33 per cent. in the total electricity sold for domestic purposes by the Cape Town undertaking is also noteworthy.

As regards the operation of the various stations, it is noted that the capacity of the plant at the Colenso station in Natal was increased by 25,000 kW. This station supplies ten towns in Natal in bulk, a large number of industrial and mining consumers, as well as consumers resident in areas extending from south of Pietermaritzburg to Wakkerstroom and Amersfoort in the Transvaal and to Bethlehem in the Orange Free State. Its output was 281,191,807 kWh, the maximum demand being 53,560 kW, the load factor 59·9 per cent., and the thermal efficiency, based on the electricity sent out, 17·8 per cent. While the output of the Colenso station just recorded showed an increase of 11·1 per cent. over the 1938 figure, that of the Witbank station was lower. This is explained by the fact that an extensive programme of overhaul was undertaken and that for a period the turbo-alternators were out of service owing to the replacement of alternator stators. Actually, the sales to the Victoria Falls and Transvaal Power Company fell from 623,604,984 kWh to 587,212,218 kWh, a decrease of 5·8 per cent., though this was counterbalanced, to some extent, by increased sales to the mining and industrial undertakings and for domestic and lighting supplies. On balance, therefore, the total output of the station was 678,805,550 kWh, a decrease of 3·8 per cent. compared with 1938. In addition, the undertaking sold 89,415,787 kWh to the Railway Administration, representing an increase of 40·87 per cent. over the corresponding amount for 1938. This was purchased partly from the Victoria Falls Power Company and partly from the Pretoria Corporation. Thus the total sales from the Witbank undertaking in 1939 were 767,741,727 kWh, compared with 768,114,272 kWh in 1938, a decrease of only 0·05 per cent. The maximum hourly demand was 103,016 kW, the load factor 75·2 per cent., and the thermal efficiency 15·91 per cent.

The generating stations of the Commission and of the Corporation at Cape Town operate under a pooling agreement and hitherto the main portion of the output has been obtained from the plant at Salt River. During 1939, however, the new Table Bay station of the municipality began commercial operation and is now being employed as a base-load station. As a result, the output of the Salt River station fell from 333,587,582 kWh in 1938 to 129,224,222 kWh in 1939. The output of the Table Bay station was 247,241,860 kWh and that of the old Dock-road station 793,793 kWh, making a total of 377,259,875 kWh from the "pool" stations. The thermal efficiency of the Salt River power station was 17·7 per cent. in 1939, compared with 20·3 per cent. in 1938. The maximum half-hourly demand was 62,000 kW and the load factor 23·6 per cent., calculated on 8,736 hours. The output from the Congella station in the Durban area was 233,929,020 kWh, an increase of 25,399,459 kWh, or 12·3 per cent., over that of the previous year. The greater part of this energy was supplied in bulk to the Durban Corporation. The Congella and Colenso stations, of which mention has been made above, are now inter-connected, through the Booth substation, and the assistance which the two station are thereby able to render each other has already proved of great advantage.

The Sabie undertaking, which is the only hydro-electric generating station owned by the Commission, generated 6,757,600 kWh during the year, a decrease of 11·9 per cent. The whole of this output is supplied to two gold mining companies operating in the district. The maximum demand was 1,225 kW and the load factor was 74·85 per cent. As regards the new Vaal station, although delivery of the plant will probably be delayed by war conditions, satisfactory progress has been made in the construction of the circulating-water system, including the two hyperbolic cooling towers, each 320 ft. high, coal-handling appliances and railway sidings. All this work, it may be mentioned, is being carried out on a satisfactory financial basis.

NOTES.

ENGINEERING IN GLASGOW UNIVERSITY.

THE evolution of engineering science from the position of a branch of "natural philosophy" to the status of a separate study marked a stage in its development not less fundamental than was its practical application in the so-called "industrial revolution"; and, in less troubled times, professional engineers the world over certainly would have wished to collaborate in celebrating the centenary of so momentous an event as the founding, in 1840, of the Regius Chair of Civil Engineering and Mechanics at the University of Glasgow. It was, we believe, the first of its kind, and although Lewis Gordon, the first professor, is hardly better known to the rank and file of present-day engineers than he was to his contemporaries at the time of his appointment, that circumstance reflects in no way upon his qualifications for the post; he would have been a phenomenal man, indeed, for his reputation not to have been outshone by the brilliance of his successor, William John Macquorn Rankine. To Rankine, all fields of knowledge seemed to come alike, and there were few branches of engineering science to which he did not make some notable contribution. In his time, there was still no thought of the expansion which now makes separate subjects of civil, mechanical and electrical engineering; Rankine's professorship embraced them all, and on naval architecture as well he was an accepted authority. His influence was and still remains potent in many branches of design; for he was well described, in a comment quoted in the excellent commemorative article in *The Glasgow Herald* of September 16, as "the first really powerful thinker in this country to bring the highest mathematical resources to bear on engineering practice." Rankine died in 1872, and was succeeded by James Thomson, the brother of Lord Kelvin, who was one of the earliest to develop the large-size centrifugal pump. He was followed, in 1889, by Archibald Barr, who is probably remembered chiefly for his collaboration with Dr. Stroud in the production of the Barr and Stroud range-finder, but who left an enduring monument also in the James Watt engineering laboratories of the University, which he initiated. Barr's successor was the late Professor J. D. Cormack, during whose tenure of the Chair the centenary of the death of James Watt provided an occasion for the establishment of two new Chairs, in Heat Engines and Electrical Engineering, respectively. They were actually founded in 1921 and, with the existing John Elder Chair of Naval Architecture, completed (at least, for the time being) the sub-division on modern lines of the comprehensive curriculum that Rankine had undertaken single-handed, and which his own work had done so much to expand. It is permissible, perhaps, to wonder how the popular attitude towards engineering in general might have been affected if its study had continued under the earlier title. There is a sense of detachment from things mundane about the word "philosophy"; while there is more than a suspicion that engineering, the science, has suffered by confusion, in the public mind, with engineering, the manufacturing industry. Be that as it may, there can be no question that mankind, in general, has benefited materially by the closer liaison between theory and practice, initiated in Glasgow.

AIR RAIDS AND INDUSTRY.

While the general trend of events continues to point ever more positively to an ultimate British victory, there are, as yet, no indications of the approximate date of its achievement. It may be taken as a sound general principle, however, that the attainment of such a goal depends entirely upon the vigour with which it is worked for, and that every interruption of war effort, from whatever cause, is a postponement to some extent of the desired result. The bravery and devotion to duty of the civil-defence services were deservedly commended by His Majesty the King, in the broadcast speech in which he announced, on Tuesday last, the establishment of the George Cross and Medal; but it has been disquieting to find, in so many quarters which might have been expected to give a lead in the determined avoidance of interruption, such a preoccupation with the incident of the moment and an apparent tendency to ignore the larger issues. The wholesale closing of post offices at the first warble of the syren is at last to be modified, though, it appears, not entirely abandoned. Banks, transport services, and industrial establishments are to maintain their normal routine as far as possible, until an immediate menace becomes evident; and Government departments, it is understood, are to modify considerably their present practice in the matter of taking cover. It remains to be seen whether some relaxation may be made in the drastic restrictions on telephone communication, which at present constitute a serious drag on industry. Some self-denial in private telephoning is obviously necessary, but urgency is not an attribute only of official calls. A flat refusal to accept any other than official calls to some exchanges almost inevitably creates one of two impressions: either that the district concerned has suffered exceptionally severe damage, or that officialism is being allowed to get out of hand. At first, the former explanation was freely surmised, but experience of a few raids and eventual knowledge of the damage done—which cannot be hidden indefinitely from the ordinary public—is leading to a widespread acceptance of the other view. The general appointment of fire watchers, in accordance with the recent Defence Regulation, who are to be on duty at all times in premises where more than 30 persons work, may effect a reduction in the number of "official" calls by what is virtually a large-scale decentralisation of fire-preventive supervision; but it may easily involve a corresponding demand for non-official calls of unquestionable urgency. If such calls as these, and the hardly less urgent messages of those who are endeavouring to carry out their own essential repairs, are to be held up indefinitely at the outgoing switchboard by some all-embracing "stop" order, it is open to doubt whether the advantage gained by keeping all junctions constantly clear for departmental demands represents an adequate compensation for the delay and interruption involved to industry and the community in general.

BRITISH TRADE WITH SOUTH AMERICA.

The war has severed many old-established trade connections with the greater part of Europe, but it is satisfactory to learn that trade with other parts of the world, especially with South America, is being well maintained. As has been pointed out in our columns on several occasions, this market deserves further attention, especially because, while British command of the sea has removed German competition, there is still a powerful, if friendly, rivalry from the United States. Considerable importance, therefore, attaches to the mission, headed by Lord Willingdon, which is to leave this country for South America early next month. A part of the mission's duties, admittedly, will be diplomatic, in that it will seek to explain British war policy and to counter German propaganda; but it will also be charged with the delicate task of reconciling South Americans to the necessity of the British blockade and of convincing them of the certainty of an ultimate British victory. On the trade side, the mission will aim at convincing South American buyers, in face of the most vigorous enemy propaganda, that this country is able as well as willing to supply goods formerly imported from Germany and other Eiropean countries. It is not intended, however, that the mission shall undertake the negotiation of trade agreements. As a large proportion of these goods were of an engineering character, it is, however, unfortunate that that industry is not more largely represented on the mission. Among its members are Mr. Hugh McGill, of Messrs. Platt Brothers, the well-known textile-machinery makers, and Mr. C. S. Richards, joint managing director of Messrs. Metropolitan-Vickers Electrical Export Company, who is well acquainted with South American conditions, but for the rest, engineering representation is lacking, though it is understood that members of other export groups have been invited to accompany the mission. Otherwise, the body seems to be well equipped for its task, which includes both short and long range problems. Among the latter is the storage of stocks until European countries are again able to buy them. In dealing with this particular difficulty, there are indications that active assistance will be forthcoming from the United States, thus providing yet another example of their sympathy with the British cause.

A NEW SCRAP CAMPAIGN.

Though there is good reason to believe that the recent campaign for the collection of scrap has been successful, it, is essential that the effort should be maintained and that fresh sources of supply should be discovered, if possible. With this end in view, Mr. Herbert Morrison, Minister of Supply, is undertaking a comprehensive national survey to assess and record all the bigger sources of potential scrap metal in the country. This survey will cover every condemned bridge and derelict building and every abandoned mine and quarry. It will also cover disused steel towers, mine and railway tracks and every large structure which might yield scrap metal. It is understood that the survey will be carried out first in the counties of Somerset and Glamorgan, and will be extended later to other parts of the country. This does not mean that there is a present shortage of scrap, but rather that it is desirable to take all possible steps to prevent such a condition. It will be obvious to those who travel about the country that, in spite of the appeals that have been made and the energy that many people have shown in response to them, there is still much waste material that could be collected. Incidentally, by helping to clean up hedgerows, commons, and other dumping grounds, the collection should perform a real social benefit. In one way, this campaign is being materially supported by the enemy; the numerous German aeroplanes that have been destroyed during the past few weeks have provided a useful contribution towards the requirements of aluminium and other metals. It is to be hoped that, difficult as the search may be, even small amounts of material will not be neglected, since in the aggregate they should provide an important contribution.

THE OPERATION OF AUTOMATIC RECLOSING CIRCUIT BREAKERS.

The thirty-fifth annual report of the Rand Water Board, to the contents of which we made a general reference on page 239, *ante*, contains some specialist information of interest to electrical engineers, of which separate mention may be made. The pumping stations at Zwartkopjes, south of Johannesburg, and Zuurbekom, some sixteen miles west of the city, are connected by a 16·5-kV transmission line, which, during the year ended March 31, 1940, was cut out twelve times owing to the operation of the protective equipment. Only in one instance, however, was the line damaged. As the result, the pumping time lost was 7·25 hours, giving a line availability of 99·92 per cent. Maintenance on the line accounted for four further outages, which aggregated 4·75 hours, giving a line availability of 99·94 per cent. Automatic re-closing was fitted on the 16·5-kV oil circuit breaker controlling this line on May 26, 1939. Since that date, eleven interruptions occurred, due to the operation of the protective gear, on ten of which the circuit breakers re-closed automatically, while on only one occasion were they locked out by a persistent time fault. The aggregate pumping time lost by the ten interruptions which were followed by immediate reclosure was 2 hr. 5 minutes, that is, an average of 12·5 minutes from the time the line circuit breaker tripped on the fault until the full output from Zuurbekom was re-established. The policy of installing this equipment may be said, therefore, to have been fully justified. In general, it may be claimed that such circuit-breakers prevent excessive time being lost owing to the occurrence of temporary faults such as those resulting in flash-overs at the insulators. The breaker itself incorporates mechanism which has sufficient power to reclose the breaker after the protective gear has opened it, a delay being introduced to enable the fault to clear. The necessary power is obtained from a strong spring, and generally, the arrangements are such that several re-closings take place before the breaker is finally locked out.

MARKETS IN BRAZIL.

(*Concluded from page* 234.)

STATISTICS given in Table IV, on this page, show the imports into Brazil in 1936 of engineering products from the three chief supplying countries, and reveal the relatively unimportant position to which British goods had fallen compared with those from the United States and Germany—the latter having been at a high level owing to "compensation" business; so that in the lines enumerated Britain should now be able to supplant Germany, although the United States continues to be the chief source of competition. Indeed, while Brazil's import trade is now concentrated in the hands of shippers from Great Britain and the United States, the latter appears to be replacing Germany, imports of North American industrial machinery, for example, having risen during 1939 by more than 50 per cent. over 1938, at 158,633 contos. Moreover, as shown in the accompanying Tables V and VI, giving imports through the Port of Santos, Brazil's chief trading inlet, of iron and steel raw materials and manufactured goods, although Germany's proportion fell by volume and value in 1939 compared with 1938, that of the United States expanded very considerably, but Britain's proportion declined to a low level. This also shows the direction in which Britain's export trade could be reasserted; particularly as, before the slump in 1930, Great Britain was accustomed to handle from 17 per cent. to 20 per cent. of the Santos trade in iron and steel goods.

At the moment, it is impossible to predict the extent to which the European situation will affect local business conditions in Brazil, although the purchasing power of the Republic may be seriously reduced by the loss of so many European markets. The latter factor particularly aggravates the problem of Brazil's over-production of coffee, which has defied solution for many years. With the United States now the only important coffee market remaining open, a recent Pan-American Conference suggested import quotas in the United States in the 1940-41 season for the various producing countries, Brazil's quota to be some 9,300,000 bags. The Brazilian coffee crop for 1940-41, however, is estimated at nearly 21,000,000 bags, and as shipments may be only 11,000,000 bags, including the United States quota already mentioned, the Brazilian Government has decided to take over 10,000,000 bags, about one-half of which will be destroyed, which will cost as much as 5,625,000*l.* sterling by way of compensation to planters. In the case of cotton, there were justifiable hopes before the war that this would prove Brazil's salvation, but prices are now steadily declining, and, while Britain will probably continue to take a much larger volume of Brazilian cotton this year, other markets are cut off or reduced, and there may be a large carry-over of cotton at the end of this season, a remark which also applies to the heavy cocoa crop this year. The loss of European markets has also resulted in a steady fall in prices of many other of Brazil's export products, while it is thought that only about one-half of the present export surplus of 5,500,000 boxes of oranges will find an outlet abroad. In these circumstances, there are already indications of a decrease in internal trade in Brazil, which may become aggravated if European hostilities are prolonged and local produce prices continue to fall. The lighter industries, especially textiles, are already feeling the effects of the reduced consumer demand. On the other hand, heavy industries and the manufacture of articles formerly furnished by Europe are on the upward trend, and this will, to a certain extent, assist in avoiding a major crisis.

Faced with the problem of over-production, Brazil, like other South American countries, is now looking towards the United States, whose task it must chiefly be to devise the necessary remedies for re-organising the foreign trade of the Southern Continent. Despite the war-time difficulties of Britain, this country has shown that she is willing to give the fullest co-operation in her power to the United States to help to solve Latin America's difficulties. Washington's realisation of the urgency of the matter is shown by the present proposals to increase the capital of the Export-Import Bank of Washington to 500,000,000 dols., such capital to be utilised to assist trade with South America, and particularly to finance the handling and orderly marketing of the large surpluses of many products. The British Government is making every endeavour to embark on an export drive in South America, particularly to make good the loss of markets for British goods in Europe, and arrangements have already been made to enlarge both the capital and scope of operations—particularly in South America—of the Government-sponsored organisation known as the United Kingdom Commercial Corporation. The insurance scheme of the Export Credits Guarantee Department has also been extended. The British Government has been buying Brazilian products on a larger scale than before, and sterling balances thus created are automatically earmarked to pay for British goods under the terms of the Anglo-Brazilian Payments Agreement of June 20, 1940. Under this agreement, all payments from the British Empire to Brazil and vice versa are made in official sterling through a special account between the Bank of England and the Bank of Brazil, and the rate of exchange at which the proceeds of exports to Brazil are thereby remitted is at present fixed at around 80 milreis per £, which, plus a tax of 5 per cent., gives an effective rate of about 84 milreis. At this new rate of exchange, United Kingdom prices are generally competitive in the Brazilian market, and, therefore, it should be the constant endeavour of the British authorities to see that our exporters are freed from the difficulties of being unable to quote firm prices or definite delivery terms; particularly so, as recent very prolonged delays in delivery from the United Kingdom have been prejudicial to British trade, whereas United States deliveries have been excellent. British goods would be welcome for the reason that they are cheaper than American goods, if only delivery were reasonably rapid.

As pointed out in previous articles dealing with South American markets, British manufacturers who are not familiar with trading conditions there, and who may wish to take the opportunity of extending their markets, should be able to secure assistance from the Export Council through their appropriate Group, particularly in regard to the formalities introduced by the Defence Regulations in this country, but a brief account of the usual methods of conducting business with Brazil, as well as a short reference to the regulations in force in that country, may be of service.

Three ways of opening connections present themselves, namely, by the appointment of a local commission agent; through one of the large British importing houses established in Brazil; or by a personal visit by a representative who speaks Portuguese. This is the national language of Brazil, whereas Spanish is used in all other South American countries, so that modern salesmanship in Brazil calls for correspondence, catalogues, etc., to be drawn up in Portuguese. The Department of Overseas Trade, 35, Old Queen-street, London, S.W.1, has issued a *Memorandum on Methods of Trading with and the Appointment of Agents in Brazil*, and this booklet also contains valuable information on customs and consular requirements, shipping documents, packing, advertising, catalogues and many other matters. In Brazil, British commercial interests are ably cared for by the British Chamber of Commerce in Brazil, Rua Visconde de Inhauma No. 91, Rio de Janeiro, and by the British Chamber of Commerce of São Paulo and Southern Brazil, Rua São Bento No. 355, São Paulo, both of which are invaluable sources of

TABLE IV.—CHIEF COUNTRIES SUPPLYING ENGINEERING PRODUCTS TO BRAZIL IN 1936.

	United States.		Germany.		Great Britain.	
	Volume, Metric Tons.	Value, Milreis.	Volume, Metric Tons.	Value, Milreis.	Volume, Metric Tons.	Value, Milreis.
Copper, smelted, rolled or hammered	3,844	15,266,575	2,400	12,481,696	535	2,909,233
Iron, bar and rod	925	865,146	23,718	20,035,430	87	121,311
Motor-cars, lorries and chassis	17,402 units	176,853,351	1,288 units	17,531,548	155 units	2,959,072
Accessories for same (except tyres)	1,221	16,250,153	93	2,266,670	29	839,667
Railway cars and wagons	400 units	14,595,548	74 units	5,280,573	17 units	1,887,454
Electric cables (copper)	19	458,928	136	547,475	825	5,770,512
Iron sheets	1,870	2,653,262	1,057	1,469,473	1,925	2,799,957
Tinplate in sheets	21,029	37,270,233	16,885	35,322,327	2,844	5,760,158
Iron superstructure for building	1,752	3,950,387	5,962	9,291,566	1,002	1,548,693
Rails and accessories	21,324	16,291,445	12,705	12,153,571	1,198	1,590,803
Locomotives	2 units	1,104,025	51 units	21,181,578	4 units	2,296,658
Electric motors	240	3,145,834	109	2,013,842	85	1,283,174
Electric transformers	274	3,933,138	452	4,976,799	439	5,838,967
Iron tubes, pipes and joinings	2,773	7,864,767	16,608	26,299,688	4,749	7,296,553

TABLE V.—IMPORTS THROUGH SANTOS FROM COUNTRIES SUPPLYING IRON AND STEEL "RAW MATERIAL" GOODS.*

	1938.				1939.			
	Volume.	Value.	Percentage of Total.		Volume.	Value.	Percentage of Total.	
	Metric Tons.	Contos.	Volume.	Value.	Metric Tons.	Contos.	Volume.	Value.
Germany	18,137	30,685	45·9	50·3	10,140	16,433	20·9	24·1
United States	12,808	16,709	32·5	27·5	26,574	36,616	54·9	53·4
Great Britain	2,274	4,879	5·7	8·0	1,125	2,217	2·3	3·2
Belgium	3,973	4,641	10·0	7·6	8,358	9,918	17·3	14·4
Others	2,318	4,092	5·9	6·6	2,180	3,313	4·6	4·9
	39,510	60,916	100·0	100·0	48,377	68,497	100·0	100·0

Note.—1 conto = 12*l.* sterling, approx.

* Consisting of pig and cast iron, iron and steel bars, rods, beams, sheets, strip, wire, discs, and angle, tee and other building iron and steel.

TABLE VI.—IMPORTS THROUGH SANTOS FROM COUNTRIES SUPPLYING IRON AND STEEL MANUFACTURED GOODS.*

	1938.				1939.			
	Volume.	Value.	Percentage of Total.		Volume.	Value.	Percentage of Total.	
	Metric Tons.	Contos.	Volume.	Value.	Metric Tons.	Contos.	Volume.	Value.
Germany	22,094	53,892	35·2	40·6	14,007	34,627	18·7	23·3
United States	23,613	41,139	38·3	31·0	38,923	71,740	51·9	48·3
Great Britain	6,780	17,384	10·9	13·1	5,574	12,741	7·4	8·5
Belgium	1,870	2,727	3·1	2·1	5,273	7,932	7·0	5·3
Others	7,746	17,361	12·5	13·2	11,121	21,440	15·0	14·6
	62,103	132,503	100·0	100·0	74,898	148,480	100·0	100·0

Note.—1 conto = 12*l.* sterling, approx.

* Consisting of tinplates, rails, junctions and accessories for railways, tubes, pipes and accessories, barbed wire, iron and steel wire, and sheets for roofing and culverts.

information on market conditions and regularly issue most informative bulletins in English. Reports on marketing conditions, agencies, etc., in Brazil are also available at the Bank of London and South America, Limited, 6, Tokenhouse-yard, London, E.C.2, which has many branches throughout the Republic, as well as at the British and Latin American Chamber of Commerce, 11A, Union-court, London, E.C.2.

The most agreeable time for visiting Brazil is the winter, from May to October, as summer conditions all over the country are tropical. Generally speaking, there are no fixed buying seasons except for textiles. The main centres of distribution are Rio de Janeiro (the capital) and São Paulo, with a fair import trade through Pernambuco in the north and Rio Grande do Sul in the south.

The metric system is employed throughout South America and the use of British measures should be avoided, therefore, in quotations and estimates. The unit of currency in Brazil is the *real* (plural, *reis*), which is of such small denomination that amounts of less than 100 reis are not now recognised. One thousand reis are equivalent to one milreis (written Rs.1$000), which is the usual basis for quoting prices, and one thousand milreis are known as a conto of reis; contos are used for expressing relatively large amounts. The old custom persists in London of quoting the Brazilian rate of exchange in pence per milreis, but this method is not employed in Brazil, where the sterling rate is quoted in milreis to the £—a much more simple way of conversion from the one currency to the other.

The financing of exports to Brazil is an important point, and a large proportion of trade is conducted by means of documentary bills sent through a bank for collection; letters of credit may also be opened, allowing payment to be obtained against presentation of documents in London. When bills are sent for collection they are often drawn at sight, but the general term is about 90 days' sight, while even longer terms are sometimes allowed. As in the case of exports to Argentina, payment for goods shipped from the United Kingdom to Brazil is required, under the British Defence Regulations, to be received here within six months. However, if there is an adequate reason for granting credit terms which would not enable the proceeds to be received within the six-months period, it is usually possible to obtain an extension of time from the authorities.

No import permit is required in Brazil before goods are ordered abroad, but a permit to buy the necessary foreign exchange must be obtained, and this will not be granted until the goods have been cleared from the Customs. This rule raises a difficulty in regard to goods sold on "cash against documents" terms, which, however, is satisfactorily solved by the British exporter authorising the collecting bank to deliver the documents to the importer against a deposit in local currency at a provisional rate of exchange. The shipper is thus amply secured until the buyer has completed the customs and exchange formalities preparatory to securing the necessary foreign currency.

Some nervousness appears to remain in the minds of exporters contemplating business with Brazil, owing to the fact that some years ago certain arrears of commercial debts in foreign currencies became "frozen" and creditors had to accept part payment in bonds. These bonds have now all been repaid and there has been no fresh accumulation of debts. It is true that the situation for many export products is at present unsatisfactory, but even if the exchange position deteriorates as a result, there is reason to suppose that the Brazilian Government will again give preference to imports—especially engineering and other capital goods of prime necessity for the country's development—in distributing available supplies of exchange, since this policy was successfully pursued throughout 1938, when a period of exchange stringency followed the readjustment of coffee prices in the previous year. Moreover, as already emphasised, the British Government is now buying Brazilian products on a larger scale than before, and sterling balances thus created are automatically earmarked to pay for British goods under the terms of the new Payments Agreement.

THE LATE MR. ANDREW T. REID.

MANY of our readers will learn with regret of the death of Mr. Andrew Thomson Reid, which occurred in Glasgow on September 16. Mr. Reid, who had been connected with the locomotive-building industry all his life, was chief managing director of the North British Locomotive Company, Limited, Springburn, Glasgow, 11. He was a son of the late Mr. James Reid, who, in the middle of last century, joined Messrs. Neilson, Reid and Company, Hyde Park Locomotive Works, Glasgow, a firm founded in 1837. Mr. A. T. Reid was born on July 17, 1863, and entered Glasgow Academy at the age of nine. He subsequently attended Loretto School, Musselburgh, which he left in 1881 to undergo scientific training at the University of Glasgow. In 1883 he commenced a five years' pupilage in the firm of Messrs. Neilson, Reid and Company. His training was thorough and he worked successively in the pattern shop, foundry, and smithy, and in the fitting, machine, boiler and erecting shops, finally spending some 18 months in the drawing office. In 1888, upon the completion of his pupilage, he was engaged in the estimating and purchasing departments of the company, and continued in this capacity until January, 1893, when he was made a partner in the firm and took an active part in its management. When the North British Locomotive Company, Limited, was established as a limited company in 1903, by the amalgamation of Messrs. Neilson, Reid and Company, Messrs. Sharp, Stewart and Company, Limited (founded in 1828 in Manchester), Atlas Works, Glasgow, and Messrs. Dubs and Company, (founded in 1864) Glasgow Locomotive Works, Glasgow, Mr. A. T. Reid was appointed managing director of the Hyde Park Works of the Company. In this position he had full charge of the design and manufacture of the locomotives constructed by the firm. Some years later, he was made chief managing director of the North British Locomotive Company, Limited, and continued to occupy this position until his death.

Mr. Reid was elected a member of the Institution of Mechanical Engineers in 1897 and of the Institution of Civil Engineers on December 6, 1904. He was for many years a Justice of the Peace and Deputy Lieutenant of the City of Glasgow, and the County of Perthshire. He was the recipient of the Volunteer Officers' Decoration and was gazetted a Lieutenant-Colonel in 1907. Mr. Reid resided for many years at Auchterarder House, Auchterarder, Perthshire. He was unmarried and was the last survivor of four brothers who joined their father in the family locomotive business and took an active part in its development. His three brothers were Sir Hugh Reid, Bart., Sir John Reid, and Mr. W. M. N. Reid.

THE LATE MR. THOMAS ROLES.

BY the death of Mr. Thomas Roles, which occurred at Bradford on Monday, September 9, in his sixty-fifth year, the electricity-supply industry has lost a popular figure. He had been connected with the industry from the very early days and was well-known as an enterprising and energetic chief of an important municipal undertaking.

Thomas Roles was born in Brighton and was educated at schools and the technical college in that town. He received his electrical training with Messrs. The Electrical Supplies and Fittings Company, Limited, and with the well-known firm of Messrs. Crompton and Company, by whom he was subsequently employed on the installation of generating plant for the Hove electrical undertaking. On the completion of this work he entered the service of the Hove Electric Lighting Company and afterwards held the positions of chief assistant electrical engineer at Aberdeen, and draughtsman and mains engineer with the Leicester Corporation. In 1900, he became generating engineer to the Poplar Borough Council and four years later was appointed chief assistant engineer at Bradford. He succeeded Mr. A. S. Blackman as chief engineer in 1907 and held this position until his retirement only a few weeks ago.

During his tenure of this office the undertaking expanded enormously, its growth being particularly marked during the past few years. It comprises a "selected station" at Valley-road, with a total capacity of 102,000 kW, the equipment including a boiler with an output of 75,000 lb. per hour at a pressure of 1,100 lb. per sq. in. This boiler supplies a 2,500-h.p. back-pressure turbine which is superimposed on the rest of the station and provides one of the few examples of this class of installation to be found in this country. In 1938, the station had the low coal consumption of 1·47 lb. per kilowatt-hour generated, with a thermal efficiency of 18·71 per cent. The output in 1938-39 was 172,510,900 kWh, and the total load connected amounted to 359,707 kW. Mr. Roles was an energetic advocate of cheap electricity for domestic purposes and, before the 1914-18 war, was one of a small group known as the "Point Fives," membership of which was confined to those who had a tariff of 0·5*d*. per kilowatt-hour, or less.

Mr. Roles was elected an associate member of the Institution of Electrical Engineers in 1901 and was transferred to the grade of member in 1912. He had served on the Council and as chairman of the North Midland Centre. He was an energetic member of the Incorporated Municipal Electrical Association and served as president in 1920. At the time of his retirement he was serving on the Council. He was also a member of the Consultative Committee of the Central Electricity Board and of the Council of the Electrical Development Association.

THE LATE MR. W. H. BLAKER.

WE regret to record the death on September 12, at Weymouth, of Mr. W. H. Blaker, M.Inst.C.E., formerly chief engineer to the Isle of Man Harbour Commissioners. He was 65 years of age, and had been living in retirement since 1936.

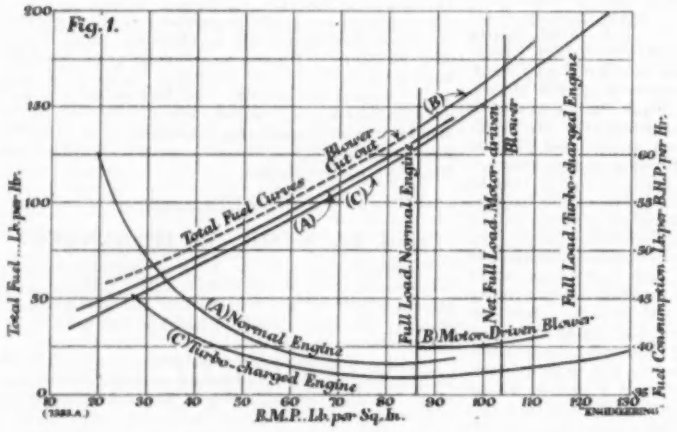
William Herbert Blaker was born on June 12, 1875, and received his general education in South Africa, first at St. Charles Grammar School and subsequently at Pietermaritzburg College. He matriculated at the Cape of Good Hope University, but in 1893 came to London, where he studied for 3½ years at the Crystal Palace School of Engineering. This course was followed by a year's training under Mr. P. Nevill, chief assistant to the late Mr. James Walker, M.Inst.C.E., who then held the position of chief engineer to the Isle of Man Harbour Commissioners, to which Blaker ultimately succeeded. During 1897, he was employed as resident engineer on the extensions to the Queen's Pier at Ramsey, I.O.M., and in the following year, when James Walker was appointed chief engineer to the Tyne Improvement Commission and Nevill became chief engineer in the Isle of Man, Blaker was made chief assistant. In this position he remained until 1900, carrying to completion the Queen's Pier at Ramsey, and being concerned in various other works of harbour maintenance.

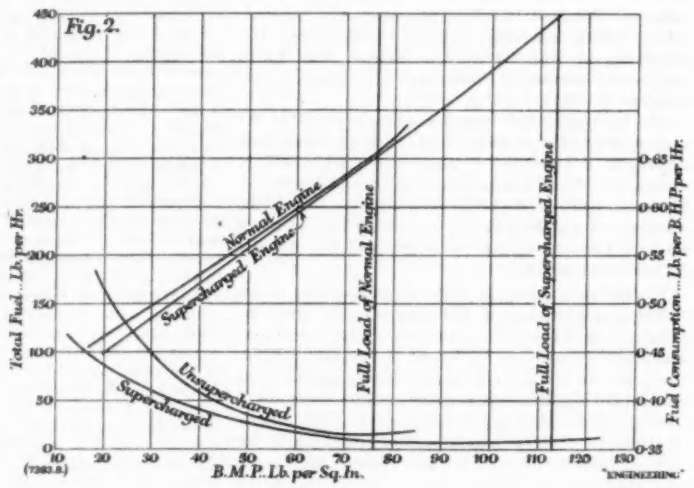
In 1900, Blaker returned to South Africa, where he was engaged for four years as an assistant engineer with Sir John Jackson, Limited, contractors for the Simon's Bay naval dockyard, Cape Colony, being chiefly concerned with the design and supervision of works at the quarries, as well as with dwellings and workshops, and certain of the permanent jetties. In 1904, he was appointed divisional engineer of the Congella development scheme at Durban, by the Natal Government Harbour Department, and took charge of dredging and reclamation work, but he relinquished this post in the following year in order to return to the Isle of Man as the Harbour Commissioners' chief engineer, the position which he continued to occupy until, as stated, he retired in 1936. During his tenure of this office he was responsible for extensive repairs to the old Battery Pier and the widening of the Victoria Pier, both at Douglas; the Raglan Pier at Port Erin; the reconstruction of quays at Ramsey; promenade improvements at Douglas; and various dredging and other operations in connection with the maintenance of the harbours in the island.

Mr. Blaker's most important undertaking, however, was the preparation and execution of the harbour improvements at Douglas. The original project, initiated by the Isle of Man Government, would have involved an expenditure of nearly 750,000*l*. This being found to be financially impracticable, Mr. Blaker prepared a less ambitious scheme, to cost little more than a third of this sum, and this scheme included the construction of a new pier inside the harbour and a causeway linking it with the landward end of the existing Victoria Pier. This new King Edward VIII Pier, as it was named, was officially opened in 1936 by Sir John Simon (now Lord Simon). In addition to his duties as chief engineer to the Harbour Commissioners, Mr. Blaker acted in an advisory capacity to the Lieutenant-Governor in various engineering matters, and, when necessary, held the official inquiries into railway accidents, boiler explosions, etc. He was elected an associate-member of the Institution of Civil Engineers in 1908, and was transferred to the grade of member in 1929.

EDLER PROCESS FOR RE-SHARPENING FILES.—Two methods of file reconditioning are familiar to engineers. One of these is to soften, machine, re-cut and re-harden the file, and the other is to employ acid etching. In this second process care has to be taken to prevent undercutting, which would lead to crumbling of the file in use. Messrs. A. Edler, Torrens-street, City-road, London, E.C.1, inform us that they have developed a technique of file reconditioning by the etching process in which there is no risk of under-cutting. They claim that the control is such that a file can be re-sharpened five or six times without loss of efficiency. A plant capable of dealing with 5,000 files a day has been put down.

FIFTY YEARS OF PRESSURE CHARGING.





LETTERS TO THE EDITOR.

FIFTY YEARS OF PRESSURE-CHARGING.

TO THE EDITOR OF ENGINEERING.

SIR,—We have no desire to take part in the controversy which is being conducted through the medium of your columns on the relative merits of pressure-charging by means of exhaust turbo-driven blowers compared with supercharging by means of motor-driven or engine-driven blowers, as we supply our engines with either type of supercharging according to the circumstances of the case. In consequence, we are in possession of results of both types of supercharging on exactly the same type of engine, and this enables us to answer some of the points that have been raised in the various letters you have published.

In Fig. 1 we show the fuel-consumption curves for a six-cylinder engine running at 750 r.p.m., (A) as a normal engine developing a power of 340 brake horse-power; (B) when supercharged by motor-driven blower to a power of 410 brake horse-power; and (C) when supercharged by Büchi exhaust turbo-blower to 475 brake horse-power. The same type of engine is used in all these three cases, though the piston and cams were modified as necessary to provide overlap and scavenging in the two supercharging examples, and the curves show the results under the best conditions for each system.

These curves show that with the turbo-blower supercharging there is a considerable improvement in fuel consumption throughout the full range of loads, and also that a higher degree of supercharge and higher brake mean pressure are possible with a lower exhaust temperature. With the motor-driven supercharging, there is a loss in economy immediately the blower is started up owing to the power taken to drive the blower, and therefore it only pays to start up the blower to provide supercharge and scavenge after normal full load of the engine has been reached. When the blower is driven from the engine there is an increase in fuel consumption throughout the range of loads unless a friction clutch is fitted to enable the blower to be cut out. The advantage of the motor-driven blower system is that it is considerably cheaper than the turbo-blower system, costing only about half as much for the necessary equipment.

In Fig. 2, we show curves of the results obtained on a larger engine by fitting a Büchi supercharger. This engine has a normal power of 840 brake horse-power and, when supercharged by a Büchi blower, the power is raised to 1,250 brake horse-power. The curves show that not only is there a slight increase in economy for the supercharged engine at the load corresponding to the normal full load of the engine, and that this economical running is maintained throughout the increase in load, but also there is a distinct improvement in fuel consumption at the lighter loads. Prior to our experience with supercharging, we expected the fuel consumption of a supercharged engine to be the same as that of the unsupercharged engine up to the normal full load, but this considerable improvement in economy at lighter loads has now been proved on several engines. This improvement does not occur when supercharging by motor-driven blower.

The supercharged type of engine is precisely the same as the unsupercharged engine, with the exception that the cams are modified to provide greater overlap for scavenging. The size of the fuel-pump plunger is increased to provide the extra fuel for the higher load, and the piston head recesses are deepened to give clearance to the valves, this being the only change in combustion chamber between the two engines.

Yours faithfully,
MIRRLEES BICKERTON AND DAY LIMITED,
P. JACKSON,
Chief Engineer.

Hazel Grove,
Near Stockport.
September 10, 1940.

SPECIFIC SPEED OF PUMPS AND TURBINES.

TO THE EDITOR OF ENGINEERING.

SIR,—The correspondence on the above subject, initiated by Mr. Jennings, has produced much interesting material during the past few weeks and has covered the subject very fully. The writer suggests, however, that one aspect has so far escaped notice by your correspondents, or, at any rate, has not been mentioned; that is, the actual physical interpretation of the various expressions suggested. Mr. Johansen, in his letter published on August 2, mentions that "the impossibility of assigning a physical concept to symbols like $P^{\frac{1}{2}}$ or $H^{\frac{3}{4}}$ is not least among the difficulties inherent in the usual expressions for specific speed," and Mr. Jennings, in his letter published on August 9, says that "specific speed cannot be regarded as a speed at all, but only as a dimensionless parameter. . . . Its physical dimensions cannot be the same as those of a rotational speed." Certain text-books, too, which the writer has seen, definitely state that the expression $\frac{N Q^{\frac{1}{2}}}{H^{\frac{3}{4}}}$ has no physical meaning.

This is certainly untrue, for the above expression can be clearly interpreted as the speed at which a model of the pump under discussion would deliver unit quantity against unit head. If we consider a pump discharging a quantity Q against a head H at a speed N, then, by the familiar affinity laws for a centrifugal pump, it will discharge a quantity $\frac{Q}{\sqrt{H}}$ against unit head at a speed $\frac{N}{\sqrt{H}}$. A model is now assumed to be constructed to a scale of $\sqrt{\frac{H}{Q}}$ of the original, and would discharge unit quantity against unit head at the specific speed $\frac{N Q^{\frac{1}{2}}}{H^{\frac{3}{4}}}$. This expression may not have the dimensions of a rotational speed, but at any rate it has a clear physical interpretation.

The expression derived by Mr. Jennings, $\frac{N Q^{\frac{1}{2}}}{(g H)^{\frac{3}{4}}}$, and the characteristic number of Professor Hanocq quoted by Mr. Cameron, $R = \frac{Q N^2}{(2g H)^{\frac{3}{4}}}$, are obviously closely related, the second being the square of the first with the substitution of $2g$ for g in the denominator. Both fulfil requirements in being dimensionless, but it may be pointed out that the first formula with the substitution of $2g$ for g, *i.e.*, $\frac{N Q^{\frac{1}{2}}}{(2g H)^{\frac{3}{4}}}$, has a physical significance, being the speed at which a model of the pump under consideration would have to run in order to discharge unit quantity at unit velocity through an ideal nozzle which transforms the whole head into velocity energy. If a pump is discharging a quantity Q at a speed N through a nozzle which sets up a resistance equal to the whole head H, the theoretical velocity of efflux V will obviously be $\sqrt{2g H}$. To secure unit velocity the speed must be reduced to $\frac{N}{V}$ and the quantity to $\frac{Q}{V^2}$. A model is now imagined to a scale $\sqrt{\frac{V}{Q}}$, and this will discharge unit quantity through the nozzle at unit velocity at a rotational speed

$$\frac{N Q^{\frac{1}{2}}}{V^{\frac{3}{2}}} = \frac{N Q^{\frac{1}{2}}}{(2g H)^{\frac{3}{4}}}.$$

It is helpful to many people to be able to assign a definite physical concept to a mathematical expression, and the writer's excuse for adding to this already lengthy correspondence is that the interpretation of the two formulæ explained above may not be generally realised and may commend their use to the practical engineer.

Yours faithfully,
A. W. GUPPY, B.Sc.(Eng.),
A.M.I.Mech.E.

"Powerstock,"
Bromham, Bedford.
September 13, 1940.

THE LATE SIR J. J. THOMSON, O.M., F.R.S.

TO THE EDITOR OF ENGINEERING.

SIR,—The tribute to the memory of Sir J. J. Thomson, contained in your issue of September 6, must have recalled many memories to those who are fortunate enough to have known him. I was privileged to be present at one of the last public appearances of Dr. H. M. Butler, Thomson's predecessor as Master of Trinity. This was on the occasion of a dinner given in the summer of 1917 in the Hall of Trinity College, to the cadets of No. 5 Officer Cadet Battalion, who had just qualified for commissions. After a concentrated course of instruction along Army lines, the cultured scholarly charm of such eloquence as Dr. Butler's made a lasting impression. It seemed difficult then to imagine anyone capable of matching his felicity and graciousness. Since then I have listened to his successor in the same place though in rather different circumstances, and I think that all those who have shared these experiences will agree that, by his deftness and aptness, "J. J." worthily upheld a great tradition.

In the spring of 1917 I had the good fortune to be taken round the Cavendish Laboratory by Sir J. J. Thomson himself and when, in 1919, I returned to Trinity as an undergraduate, I made a point of attending all the lecture courses he gave. It was always an inspiration to hear him discourse on any physical subject, and particularly on those branches to which he had made such outstanding personal contributions. Perhaps one of the works which best exhibits his qualities as a teacher is his *Applications of Dynamics to Physics and Chemistry*.

He has commented revealingly upon the topic of lecturing in his fascinating volume of *Recollections and Reflections*: "There is no better way of getting

FLAMEPROOF RESISTANCES FOR MINING WORK.

CONSTRUCTED BY MESSRS. METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED, MANCHESTER.

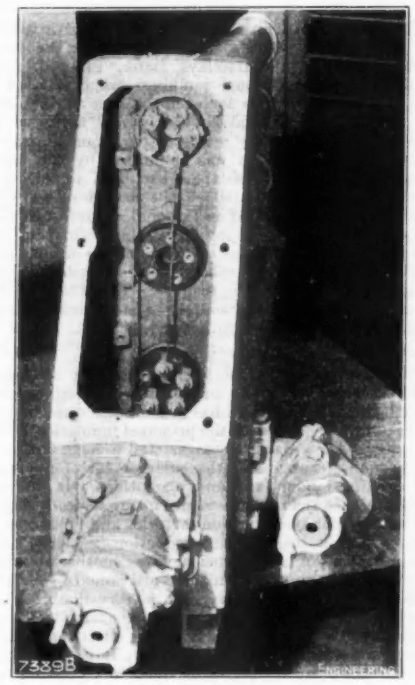


FIG. 1. TERMINAL CHAMBER.

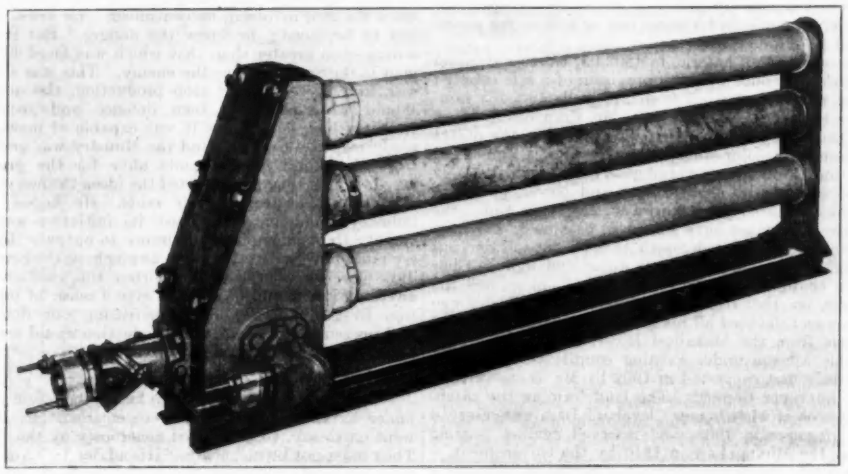


FIG. 2. THREE-UNIT FLAMEPROOF RESISTANCE.

a good grasp of your subject, or one more likely to start more ideas for research, than teaching it or lecturing about it, especially if your hearers know very little about it, and it is all to the good if they are rather stupid. You have then to keep looking at your subject from different angles until you find the one which gives the simplest outline, . . ." He might have substituted "subjects" in place of "subject" in the above, for he had a somewhat disconcerting habit of pushing his spectacles up on his forehead and directing his gaze upon some individual member of his audience. He remarked on a more private occasion that his habit in lecturing was to single out, and fix his eye on, the least intelligent person present. I fancy he must have been a trifle hesitant in his choice, for a good many of his hearers gained the impression that they were coming in for more than their fair share of his attention.

The occasion calls for some fitting commemoration of Thomson's enduring contributions to physical science. It is to be hoped that the possibility of publishing a collected edition of his scientific papers will not be overlooked.

Yours faithfully,

G. F. HERRENDEN HARKER.

Department of Physics,
University college,
Cardiff.
September 17, 1940.

COPPER DEVELOPMENT ASSOCIATION.—The offices of the Copper Development Association have now been removed to Grand Buildings, Trafalgar-square, London, W.C.2. (Telephone, ABBey 2677.) We have been asked to remind our readers that the services and publications of the Association are still available to all, free of charge. As is well known, it is an entirely non-commercial organisation, maintained by the British copper industry, and its services and staff are at the disposal of all users of copper and copper alloys.

LABORATORY FURNACES FOR HIGH TEMPERATURES.—In a recent issue of the *Journal of Scientific Instruments*, Mr. M. Pirani describes the method of constructing a small laboratory furnace for use at temperatures up to 1,950 deg. C. Briefly, the furnace consists of a tube of beryllium oxide round which is wound molybdenum wire. A second furnace, which has been found satisfactory for temperatures up to 1,900 deg. C., consists of a zirconium-silicate body fitted with tungsten heating elements, the latter being arranged so that they do not touch the refractory material.

FLAMEPROOF RESISTANCES FOR MINES.

THE resistance shown in the accompanying illustrations has been constructed by Messrs. The Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17, for use in collieries and other situations where the employment of flameproof equipment is essential. We understand that it has been passed by the Mines Department Testing Station at Buxton as proof against explosive gases in Groups 1 and 2 (methane and petroleum vapour only). It has been designed to provide exceptionally high heat-dissipating capacity in a very compact form and is thus, it is claimed, particularly suitable for installation along a mine roadway or in similar positions where the saving of space is important. It is suitable for pressures up to 600 volts, the insulator is non-hygroscopic, and other features of interest are ease of dismantling and replacement, ample wiring space, stout-bolted connections, and robust construction. The resistances are of tubular form, and are supplied in three-unit or five-unit assemblies, or in combinations of these mounted on channel-iron bases. Fig. 2 shows a three-unit assembly, from which it will be seen that an essential feature is the flameproof steel tubes containing the resistance windings. One end of these tubes is supported on a vertical bracket, while the other is sealed by flanged mounting rings into the terminal chamber illustrated in Fig. 1. This illustration enables the terminal arrangement to be clearly seen. The resistance material itself is wound in grooves on formers, which, in turn, are supported on a steel rod. It is designed to be as near the inner surface of the tube as circumstances permit, the intervening space being filled with quartz sand of high dielectric strength. This construction, it is claimed, facilitates heat dissipation. The inner surface of the tube is lined with a vitreous enamel, which provides additional insulation. Connections between adjacent formers are made by copper straps, which are bolted to terminals supported on the formers. The leads from the tapping points to the main terminals are made of stout copper rod, which runs through axial holes in the grooved formers.

Where five or more tubes are required, two or more sets of units are placed side by side, their terminal chambers being bolted together and connections from one to the other being made through flameproof bushings. The interconnections form part of the combination, and only the external leads from the motor or controller have to be made on site. As an example of a composite set of this kind, reference may be made to a bank of five sets of five-unit resistances for a 250-h.p. motor driving a main-and-tail haulage in a colliery. The whole bank is 3 ft. 4 in. high, 6 ft. long, and 5 ft. 4 in. wide. External connections are effected by sealing boxes and armoured clamps, which enable the outlet to be run in any one of five directions. For a bank of three units, a maximum of five sealing boxes, plus one for each additional terminal chamber, is permissible, and for the five-unit bank six chambers are required regardless of the number of terminal chambers. Pipe glands may be employed instead of sealing boxes for use in petrol vapour, but not in methane.

THE WATER SUPPLY OF SALISBURY, S. RHODESIA.*

By W. J. JARVIS, B.Sc. (Eng.), A.M.Inst.C.E.

THE original camp from which the city of Salisbury has developed, obtained its water supply from the Makabusi River, but it is evident that wells were sunk early in the history of the town. On September 29, 1890, one of the pioneers offered to sink wells at the following prices for a 5 ft. by 4 ft. well: for the first 20 ft., 10*s.* per foot; from 20 ft. to 40 ft., 1*l.* per foot, but if explosives were used, the prices were doubled; timbering, 2*s.* 6*d.* per foot of depth; sinking in blue bar, diorite, etc., 4*l.* per foot. During 1898-99, there were 135 wells of an average depth of 42 ft., costing about 30*s.* per foot. By 1901, these wells were showing signs of contamination. One of the chief public wells was cleaned out and 47 old buckets and tins were removed.

In December, 1900, there appeared a report by Mr. Thos. Stewart, M.Inst.C.E., on the provision of a water supply. At this stage there were 400 houses, approximately 2,000 Europeans and 1,000 natives, and consumption was estimated at 30 gallons per head per day for Europeans and 10 gallons per head per day for natives, or 70,000 gallons per day. Three schemes were suggested: (1) Hunyani River (near Railway Bridge): pumping main, 19 miles 140 yards; lift, 636 ft.; cost, 80,000*l.* (2) Hunyani River (Bulawayo Road Drift): pumping main, 10½ miles; lift, 393 ft.; pumps to deliver 150,000 gallons in 10 hours through an 8-in. steel main; cost, 60,000*l.* (3) Manyongo Stream, 6 miles from Salisbury: earthern embankment to hold 30 million gallons; 6 miles of 8-in. gravity main; cost, 58,000*l.* There was to be a reservoir to hold 220,000 gallons, or 3 days' supply, and 14·3 miles of reticulation pipes with provision for hydrants. The cost of water from scheme (3) was estimated at 4*s.* 9*d.* per 1,000 gallons for 70,000 gallons per day, and about 2*s.* 5*d.* for 150,000 gallons per day. The tariff suggested was 3*l.* per dwelling house costing 1,200*l.*, plus 5*s.* per quarter for every additional 100*l*; or 6*s.* per 1,000 gallons metered, plus 15*s.* per quarter for a ¾-in. meter, or 20*s.* for a 1-in. meter.

Mr. J. Crawford Lindsay, town engineer, in 1902, submitted a scheme placed on the Makabusi River, the source of which adjoined that of the Manyongo, River; a 15-million gallons storage, or 3 months' supply, was suggested, delivering 350,000 gallons per day through an 8-in. gravity main 2·1 miles long to filter beds. This report contained the following interesting comparisons: Durban, 60,446 population (July, 1902), consumption 3½ million gallons per day; Cape Town (September, 1901), consumption 2·12 million gallons per day; Salisbury, 4,000 (estimated) (1902), consumption 160,000 gallons per day. The power available was coal, water and wind. Coal cost 12*l.* 10*s.* per ton and wood 2*l.* per cord. Consideration was given to the installation of three windmills, 50 ft. in diameter, on the assumption that wind blowing at 15 m.p.h. for 8 hours per day would generate 33 h.p.

* Excerpt from paper read before the Institution of Municipal and County Engineers at Salisbury, Southern Rhodesia, on May 20, 1940. Abridged.

and provide sufficient power to pump the filtered water to storage. If the wind failed for a few days and water was required, it would be possible to use the steam roller, which had just arrived for road work, to drive the pump. The estimated cost of water under this scheme was 1*s.* 8*d.* per 1,000 gallons, and a tariff of 3*s.* was suggested; garden hoses could be used for 15*s.* per annum; and a water rate of 1½*d.* in the pound would be imposed.

An outbreak of enteric, in 1902-03, led to a decision to proceed at once with the provision of a safe supply; water was then derived from 215 wells and 403 rain-water tanks. In March, 1904, Mr. Crawford Lindsay was authorised to proceed to England with the object of forming a joint-stock company, under agreement with the council, to provide a good and sufficient supply of water and also electric light and power, exclusive of that required by tramways. By this time, the enteric scare must have subsided, because it was only in 1910 that the British South Africa Company sent out engineers to report again on water and light. Their water engineer, Mr. E. H. V. Melvill, examined the reports on the Hunyani, Makabusi and Manyongo Rivers and devoted all his attention to a gravitational scheme from the Makabusi River, as being the only feasible scheme under existing conditions. This was evidently first suggested in 1902 by Mr. H. Sawerthal, then Surveyor General. The land forming the catchment area of what is now Cleveland Dam was reserved from farmers in 1908, and reserved against pegging under the Mining Law in 1910 by the Government.

In 1911, negotiations with the British South Africa Company to assist in the water supply failed, and the council decided to go on with the scheme itself, at a cost of approximately 40,000*l.* The original scheme suggested by Melvill was a masonry dam to hold 100 million gallons, but trial holes showed the foundations to be decomposed granite, and an earthen dam with a puddle core was considered safer. The capacity of the dam was increased first to 150 million and then to 200 million gallons. Two slow sand filters, 50 ft. square, were suggested, but primary or prefilters were added to avoid excessive washing of sand; a slight straw colour existing in the water was removed by this double filtration. The 10-in. gravity main, 7 miles long, was first dipped in Dr. Angus Smith's composition, then wrapped with hessian cloth, and redipped; Melvill stated that he thought this was the first use in South Africa of this type of pipe protection. Reticulation mains, 3·41 miles in all, were laid to serve a possible 699 consumers. During 1913-14, *i.e.*, two years later, the actual consumers numbered 435. The primary filters were cleaned once in every four weeks and the secondary filters every ten weeks. During 1915-16, an analysis of the water showed *navicula viridis* and *pediastrum simplex* to be present. At this time there were still 220 wells in use, but 150 of the well users were connected with the town supply. Low rainfall during this year left only 80 million gallons in the dam in June, 1916; a low rainfall again during 1916-17 led to a forced reduction in consumption and to the sinking of boreholes in the town, which supplied about 160,000 gallons per day. During 1917-18, no water could be taken from the Cleveland Dam for five months, and 11 million gallons were obtained during this period from four deep boreholes. The dam was filled again in January, 1918. Consideration was then given to a supplementary water supply, and Mr. Thomas Stewart, of Cape Town, was engaged as consulting engineer. It is strange that the vagaries of the rainy season should cause such dislocation of the supply in less than five years, but history repeated itself again in 1922, 1928 and 1938.

(*To be continued.*)

COAL MINING IN THE UNITED STATES.—The average daily production of bituminous coal in the United States, during the week ending September 7, was 1,585,000 tons, compared with 1,517,000 tons in the preceding week and 1,525,000 tons in the corresponding week of 1939.

CALCITE AND FLUORITE FOR OPTICAL PURPOSES.—It is stated in a report by Mr. O. Bowles, published by the U.S. Bureau of Mines, that the Iceland deposits of calcite are practically exhausted, as regards optically-useful specimens, and that the principal source of supply in recent years has been the Kenharat district in the north west of Cape Province, South Africa. Prior to the war in Spain, however, satisfactory material had been obtained from that country. In the United States only limited supplies have so far been found, but a new deposit in the Copper Mountain mining district, some 30 miles south-west of Taos, in New Mexico, is arousing considerable interest. The deposit of calcite is large and a little of the mineral has been found to be of optical quality. The report adds that very little fluorite suitable for optical work has been found and the discovery of a good deposit of this mineral would be welcomed by scientific-instrument makers.

LABOUR NOTES.

SPEAKING at a luncheon of the Works' Management Association in London last week, Mr. Bevin, the Minister of Labour and National Service, said that he was thankful that industry had adopted the suggestion to plan a scheme for working after the sirens. He knew the risk involved, he continued. He knew what had to be faced; he knew the danger. But it was a danger no greater than that which was faced by the man in the Spitfire facing the enemy. This was a total war, and if we did not stop production, the quicker should we create our own defence and security. Industry had shown that it was capable of making a ready response to a lead and the Ministry was grateful to workers and managements alike for the prompt way in which they had adopted the ideas thrown out to minimise the effects of air raids. He hoped that industry would continue to use its initiative and ingenuity to overcome any hindrance to output. Industry must have its strategy just as much as the Services did. Everyone desired to shorten the conflict and anything that could be done to give a sense of protection to the workpeople by increasing our defences and preventing a cessation of production would materially help us to reach our objective.

Those who took great risks to keep production going under hazardous conditions were entitled, Mr. Bevin went on to say, to be treated generously by the State. They must not be niggardly. His advice to managers, trade unionists, shop stewards and everybody, was not to wait for Government regulations. Combined efforts should be made to make good any loss, and that could not be done by rigid rules. They wanted such an industrial strategy that, when the enemy made a move to impede our production, they would put their heads together and counter it.

The Joint Consultative Committee, the Minister said, had worked out a model scheme of hours of labour. It was impossible to keep on working seven days a week, and production was beginning to decline. He thought that the amount of overtime now permitted meant a great physical strain. More attention should, in his opinion, be paid to the question of hours of work and rest. Before long, they would be passing out 250,000 to 300,000 trainees a year for munitions production from the Government training centres. By means of training and transfer they had eaten into the hard core of unemployment.

Replying to a question in the House of Commons last week on the subject of unemployment among miners, the Minister of Labour and National Service said that he had arrived at an arrangement with the Minister of Mines under which there was allocated to the coal industry in May last a labour force which was calculated to meet its requirements on the basis of anticipated increased production. He had also prohibited people from leaving the industry and undertaken to direct others back to it. The collapse of France, and the loss of European markets, completely altered the situation. He had been in constant communication with the Minister of Mines regarding the problem and, in order to meet the new situation, had taken steps to modify the administration of the Order by causing a cessation of the return of people to the mines, and further by giving instructions that, in those districts where men were unemployed, they should be released for other industries.

This was, Mr. Bevin said, a national problem which he was sure, the coal industry desired to put on a national basis. At present, practically all men in the industry who were accustomed to work underground were reserved from calling up under the National Service (Armed Forces) Act. That position, he was satisfied, must be altered, and the whole matter put on a more satisfactory basis by calling up a substantial number of coal workers of the lower ages. He was in consultation with the Minister of Mines as to the numbers which should be reserved and as to the steps which should be taken to deal with the surplus. He hoped to have an early opportunity of discussing the whole problem in association with the Minister of Mines and the representatives of the organisations on both sides of the industry.

The Ministry of Labour and National Service announces that on August 31 the official cost-of-living figure was 87 points above the level of July, 1914, compared with 85 points on August 1 and 87 points on July 1. The rise of two points during August is equivalent to about 1 per cent. For food alone, the index figure on August 31, was 66 points above the level of July, 1914. This was two points, or rather more than 1 per cent., above the figure for August 1, but two points below the figure for July 1. The rise during August in the index figure for food was mainly due to increases in the prices of sugar and eggs; these increases were partly offset by reductions in the prices of potatoes. Among items other than food, the principal changes were increases, averaging between 1 per cent. and 2 per cent., in prices of clothing.

The National Arbitration Tribunal heard in public in London last week a dispute between the Bank Officers' Guild and Barclays Bank, Limited. The Guild claimed additional remuneration calculated at 5 per cent. on salaries for each advance of 10 points in the index figure, taking the normal figure as 55, the adjustments to be retrospective from January 1 last. When the claim was submitted by the Guild, the bank replied that as there had been adjustments, it did not propose to reopen the matter of war-time allowances at present. The Tribunal was informed that it was not only the rejection of the claim that was at issue, but the refusal of the bank to discuss with the Guild that or any other claim. This had been a matter of long-standing dispute. The Tribunal will issue its findings in due course. Almost similar claims against other banks were heard this week.

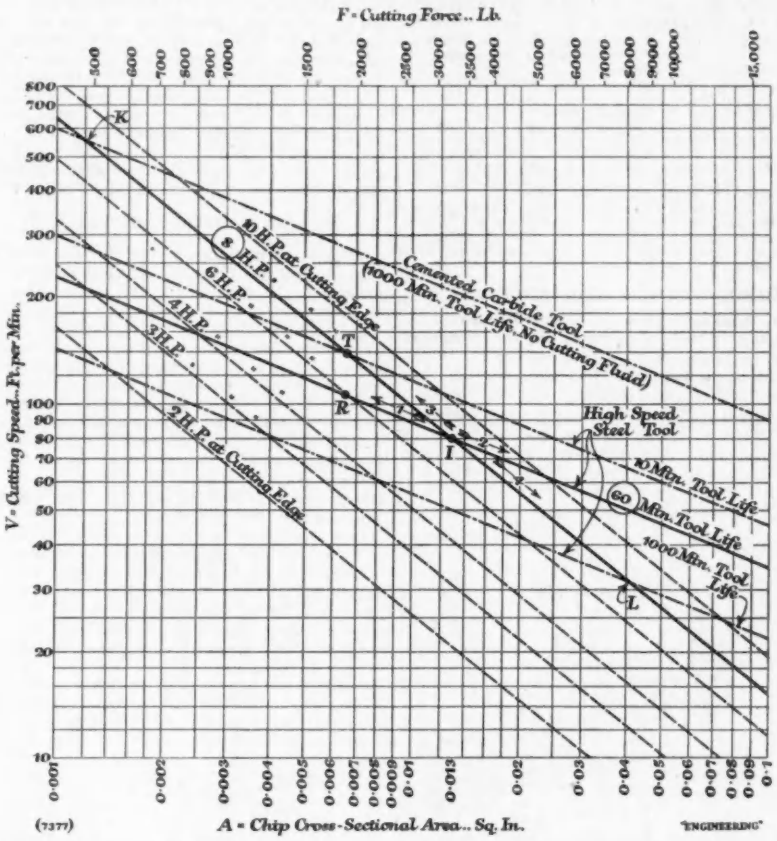
The National General Mobilisation Act of Japan, which became effective in 1939, regulating employment, wage and hours, has within less than a year spread its influence over the principal industries of that country. The legislation was enacted to meet a demand for a quick change and the enlargement of the scope of existing labour laws and regulations. It was also thought that the measure would insure a steady supply of workers for the munition factories and for industries endeavouring to increase production capacity. The improvement of labour efficiency was another objective. According to an article in the April issue of the Tokio *Oriental Economist*, however, it is very doubtful that this labour policy has operated satisfactorily for the industries or has had ameliorating effects on general economic conditions. For example, it is pointed out that labour turn-over has declined as compared with the pre-control period, and that the efficiency of labour has recently become markedly low. The wage-control provisions, which vary in different establishments and industries, have largely contributed in bringing about this undesirable situation. The programme for the development of new labour resources, which was embraced in the 1939 labour-mobilisation plan, has met with many obstacles which have impeded the rapid progress of key industries.

One of the alleged causes of the failure of labour control to operate smoothly is that in the last three years, in the words of the article referred to, the industrial structure of the Empire "has had to undergo violent transformations." Furthermore, in the industries manufacturing war products, the volume of migrant workers, including newly-recruited labourers without experience, has risen and increased the complications of labour-law administration. The casual labourers' pay has been relatively higher than that of non-transient workers which has tended to speed up labour migration. Within a given establishment a great deal of dissatisfaction has been caused in regard to wage scales and other labour-management problems. The competition for labour is growing keener and keener, through more attractive offers to the workers, and labour turn-over is on the increase. The wage scale has risen continuously since the summer of 1937, and this in turn has pushed up commodity prices.

In the opinion of the writer of the article, "these illustrations go to show how difficult it is to make actual conditions conform to laws." It seems to him that the voluntary co-operation of labour organisations toward the attainment of the goals of industrial administration is the best solution of the problem. In reply to the question as to whether existing labour unions should be expanded or whether the Industrial Patriotic Leagues should be strengthened, the author states that, as a matter of fact, the pertinent issue is whether labour organisations should be voluntary and independent. The number of Industrial Patriotic Leagues is now 23,000, with over 2,500,000 members. The growth of the labour-union movement in Japan has never been along robust lines, and what with the effects of the Industrial Patriotic League drive and the social conditions obtaining in the country, the labour-union movement is placed in a precarious position.

The official report of the United Patternmakers' Association states that in August 82 members were in receipt of Trade Benefit, as compared with 66 in the previous month. There was an aggregate increase of three on sick benefit, and the number in receipt of superannuation benefit increased from 671 to 672. The membership increased from 12,497 to 12,526.

MACHINING WITH SINGLE-POINT TOOLS.



MACHINING WITH SINGLE-POINT TOOLS.

AN interesting review of recent study in machining with single-point tools was given in three lectures delivered by Dr. M. Kronenberg, of the Research Department of Messrs. The Cincinnati Milling Machine Company, Cincinnati, Ohio, U.S.A. An account of these lectures has now been issued by the corresponding British firm, Messrs. Cincinnati Milling Machines, Limited, Woodlands Farm-road, Tyburn, Birmingham, but although this account is a condensation of the lectures, it is still too long for reproduction in our columns. The summary given below may, however, prove of some use to those who wish to follow up the subject, which has not ceased to be of importance because of the attention previously given to it by numerous investigators. Dr. Kronenberg commences with the argument that although, for practical use in shops and designing offices, cutting speeds have been determined and are to be found in many engineers' handbooks, the limits of the values given are often so wide as to prohibit accurate calculation. The wide limits, he holds, are due to the large number of factors that influence cutting speed and tool life. The cutting speed is not the constant value, even for the same material and tool, as is assumed in many tables, and the distinction made in such tables between a roughing cut and a finishing cut is an inexact concept; thus what may be a finishng cut in heavy industries may be regarded as a roughing cut by makers of precision machinery.

Different investigators have correlated the cutting speed with different variables, viz.: (1) with depth of cut and feed per revolution as separate variables; (2) with chip cross-sectional area, which is the product of depth of cut and feed per revolution; (3) with tool life; and (4) with horse-power developed at the cutting edge. The first three of these express conditions which are directly related to one another, while the fourth is related to the fundamental law of mechanics, *i.e.*, power = force × velocity. The fourth relationship, it is argued, furnishes the kep to a better understanding of the complex laws of metal cutting, and enables, together with other relationships, a basic diagram to be developed which can be employed in shop practice. Dr. Kronenberg, after this general statement, then examines in considerable detail, with pertinent tables and diagrams, the subjects of cutting speed as a function of chip cross-sectional area; cutting speed as a function of tool life; cutting speed as a function of depth of cut and feed per revolution; cutting force as a function of chip cross-sectional area; cutting pressure as a function of depth of cut and feed per revolution; and cutting force and work-piece. He then deals with what he terms a productivity diagram for selecting the most effective combination of cutting variables. This is the basic diagram for single-point tool work referred to above and is reproduced in the accompanying figure.

To establish the principles of the diagram the following reasoning is used. The turning time t for a given piece is, in general

$$t = \frac{L \times z}{f \times n} = \frac{L \times z \times d \times D \times \pi}{12 \times A \times v} = \frac{L \times D \times K \times \pi}{12 \times A \times v} \text{ minutes,}$$

where A = chip cross-sectional area (sq. in.), *i.e.*, $f \times d$; D = diameter of work-piece (in.); d = depth of cut (in.); f = feed per revolution (in.); K = stock to be removed on radius (in.); L = turning length (in.); n = revolutions per minute; v = cutting speed in feet per minute $= \frac{D \times \pi \times n}{12}$; and z = number of cuts $= \frac{K}{d}$. For the same work piece, *i.e.*, where L, D and K are constant values, the time t varies with $A \times v$, which is the chip volume in cubic inches per minute, and is dependent on the horse-power at the cutting edge of the lathe tool. The greater the available horse-power the greater becomes the permissible chip volume and the smaller the turning time. Cubic inches removed per grind are obtained by multiplying $A \times v$ by the tool life in minutes. The relationship between the cutting speed v, the chip cross-sectional area A, the horse-power at the tool P_t, and the material constant C_p follows from the fundamental law of mechanics, viz., power (P_t) = force (F) × velocity (V). Hence, $P_t = \frac{F \times V}{33{,}000}$ horse-power, and $V_{\text{ft}} = \frac{33{,}000 \times P_t}{F}$

$= \frac{33{,}000\ P_t}{C_p \times (1{,}000\ A)^r}$ ft. per minute. This formula, Dr. Kronenberg submits, may be described as the second cutting-speed law or "machine law." The first cutting-speed law, or "tool law," he describes as denoted by the formula $v = C_v \times (1{,}000\ A)^{-E_v}$, in which formula C_v = a constant depending upon material, tool, tool life and cutting fluid, and to some extent upon the shape of chip; E_v = an exponent depending upon the material to be cut; A = chip cross-section in $\frac{\text{sq. in.}}{1{,}000}$; and v = cutting speed in feet per minute for some definite tool life. It may be noted here that numerical values for C_v and E_v are given in the account of the lectures.

Comparing the "machine law" and the "tool law", it will be seen that an important fact emerges, viz., that two different relationships exist between chip cross-sectional area A and cutting speed v. This is illustrated in the productivity diagram referred to above. In this diagram the co-ordinates are the chip cross-sectional area values along the base and the cutting speed along the left-hand vertical edge, and their relationship is represented by two series of straight lines of different slope. Those with the flatter slope are drawn to the formula of the first cutting-tool law and may be called "tool lines" since they include the material of the tool represented by the C_v values. The more steeply sloped lines correspond to the second cutting-speed law and may be called "machine lines," since their position depends upon the horse-power of the machine. The method of using the diagram is to explore the inter-related variables shown and to determine their most effective combination, and is best demonstrated by taking a concrete example. It is understood that the particular diagram shown is typical and not universal; it is not applicable to other tool materials than the high-speed tool steel S.A.E. 1035, having 18 per cent. tungsten, 4 per cent. chromium and 2 per cent. vanadium. The tool has a true rake angle of 20 deg. and a cutting fluid is used.

Assuming a machine of 8 h.p. net, a high-speed steel tool of this composition which will stand 60 minutes without regrinding, and a chip cross-sectional area of 0·013 sq. in., it will be seen that the required cutting speed is 80 ft. per minute, this value being obtained from the intersection of the two appropriate lines at the point I. It may then be desired to investigate the changes in the permissible cutting speed if the area of chip be changed. (1) Following the "tool line" in the direction of the arrow 1, results in an increase of the cutting speed v and a decrease of the chip cross-sectional area A. This movement results in an approach to the "machine line" for 6 h.p., and indicates that a machine of 8 h.p. cannot be used to its full capacity if a smaller chip area than that corresponding to point I is chosen and if a tool life of 60 minutes must be maintained. The productivity of the machine would decrease considerably, as will be evident from the chip volume per minute. This decrease would be from 12·5 cub. in. per minute (0·013 × 80 × 12) at the point I to 8·2 cub. in. per minute (0·0065 × 105 × 12) at the point R. The conclusion reached is that increasing the cutting speed and simultaneously decreasing the chip cross-sectional area in such a manner that the kind of tool and the tool life is kept constant is not advisable owing to the consequent considerable decrease in productivity.

(2) Following the tool line for a 60-minute life in the direction of arrow 2, results in an increase in the chip cross-sectional area and a decrease in the cutting speed for a constant tool and tool life. The 10-h.p. line is, moreover, approached, and this indicates that such a change would result in the machine being overloaded, the conclusion being, therefore, that decreasing the cutting speed and simultaneously increasing the chip cross-sectional area in such a manner that the kind of tool and the tool life be kept constant is not advisable owing to the resultant overloading. (3) The conditions discussed under (1) and (2) both arise when the "tool line" is followed, but the machine line may also be followed from the intersection point I. If this is done in the direction of arrow 3, an increase in cutting speed is indicated with a decrease of chip cross-sectional area. It means, moreover, that the "tool line" of 60-minute endurance is left and approach is made towards the 10-minute "tool line." Since such a short tool life would be uneconomical, the kind of tool must be changed; thus, a cemented carbide tool would be required if the cutting speed were increased along the "machine line" of 8 h.p. between point I and point K. Beyond this latter point the life of a cemented carbide tool would be less than 1,000 minutes, while it is obviously much higher than this in the neighbourhood of point I. Incidentally, the line marked "High-speed steel tool, 10 min. tool life," may be taken as serving also for a cemented-carbide tool with more than 10,000 min. tool life.

A comment may here be made on the chip volume and the cutting force. The cutting force in pounds is indicated at the top edge of the productivity diagram. If the chip cross-sectional area be decreased from 0·013 sq. in. (point I) to 0·0065 sq. in. (point T) and the cutting speed increased from 80 ft. per minute (point I) to 144 ft. per minute (point T), the chip volume is decreased from 12·5 cub. in. per minute (point I) to 11·2 cub. in. per minute (point T), this condition arising from an increase in specific cutting pressure for decreasing chip cross sections. This pressure increases from 246,000 lb. per square inch (point I) to 277,000 lb. per square inch (point T). The cutting force, however, decreases from 3,200 lb. at

point I to 1,800 lb. at point T, this decrease resulting in a decrease of the load exerted on the work-piece, and, in consequence, in less deflection and a higher degree of accuracy. It is, therefore, often desirable to use small chip areas and high cutting speeds according to the direction of arrow 3. This will obviously be at some sacrifice in productivity, but will be still more advantageous than the conditions obtained by following the direction of arrow 1, where it was shown that the chip volume was reduced to 8·2 cub. in. per minute for the same area of chip, viz., 0·0065 sq. in. In addition, the use of high speeds is important for obtaining a smooth finish on the work-piece, due to the change in the behaviour of the built-up edge with increasing speeds.

(4) Following the "machine line" in the direction of arrow 4, results in a decrease of the cutting speed and an increase of the chip cross-sectional area. Here the tool life would be improved by approach to the 1,000-minute "tool line" and the chip volume would also increase. At the point L this volume would be $0{\cdot}041 \times 31 \times 12 = 15{\cdot}3$ cub. in. per minute. Thus, it would seem that the use of a low-cutting speed in connection with a big chip results in both a better endurance for the same kind of tool and a higher productivity. It must be borne in mind, however, that the cutting force increases considerably in these circumstances; for instance, from 3,200 lb. (point I) to 8,000 lb. (point L). The work-piece and the lathe bed would, therefore, be deflected to a considerably greater extent than in the case of point I, and, moreover, the feed per revolution would be coarse, both conditions being conducive to a lower degree of accuracy and poorer finish. The method of procedure along arrow 4 is only advisable if roughing cuts are to be taken on stable work-pieces. A legitimate conclusion is that the selection of, and changes in, the cutting speed as a function of chip cross-sectional area should preferably be made as dictated by the "machine line" and not in accordance with the "tool line." The tool should preferably be adapted to the speed pre-selected in this manner and not the speed adapted to the kind of tool. Increasing the speed according to the "machine line" should be accomplished by the employment of a higher quality tool and is advisable if the work-piece is unstable or if higher finish is desired. On the other hand, it is advisable to decrease the cutting speed and increase the area of chips according to the "machine line" when big work-pieces are to be rough machined.

The account of Dr. Kronenberg's lectures concludes with the expression of the view that if the general arrangement of the productivity diagram be kept in mind it will prove of great aid in anticipating the most effective combination of the main cutting variables involved. It is, further, forecast that the future development of machine tools will follow the trend of utilising power by the employment of high speeds and low forces. This implies the use of high quality tools, and, as far as the machines are concerned, in high-powered machines of rigid construction having the maximum freedom from vibration.

CATALOGUES.

Waxes and Greases for Vacuum Work.—Messrs. W. Edwards and Company (London), Limited, Allendale Works, Southwell-road, Loughborough Junction, London, S.E.5, have sent us a folder describing their Apiezon greases and waxes for sealing joints in vacuum systems, scientific apparatus, etc.

Reducing Gears.—Messrs. Sanderson Brothers and Newbould, Limited, Sheffield, have sent us two publications dealing with their Heliocentric reducing gears. These reduction units are constructed to designs which permit high ratios to be obtained in a small space with a high overall efficiency and without end thrust.

Self-Lubricating Bearings.—Messrs. The Manganese Bronze and Brass Company, Limited, Handford Works, Ipswich, have sent us a revised edition of their list of stock sizes of Oilite self-lubricating bearings. Included in this publication are the fitting and machining data which, previously, appeared in separate pamphlet form.

Furnace Gas Burners.—We have received from Messrs. The Wellman Smith Owen Engineering Corporation, Limited, Victoria Station House, Victoria-street, London, S.W.1, a catalogue describing the Wellman "Basequip K" gas burners, in which, it is claimed, instantaneous and complete combustion is achieved by giving a rotary motion to the mixture of gas and air.

Electric Lamps and Accessories.—We regret that in referring in this column, in our issue of September 6, on page 200, to the emergency-lighting equipment supplied by Messrs. Latem Electrical Company, Latem Works, Eastwood-street, Hall-lane, Bradford, the name "Latem" was incorrectly spelt. The equipment consists of a Latem incandescent lamp supplied with current from a Varley dry accumulator and is suitable for fixing in any desired position.

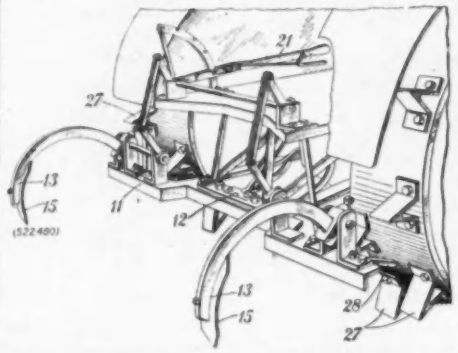
"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.
Where inventions are communicated from abroad, the Names, etc., of the communicators are given in italics.
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. *each.*
The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

AGRICULTURAL APPLIANCES.

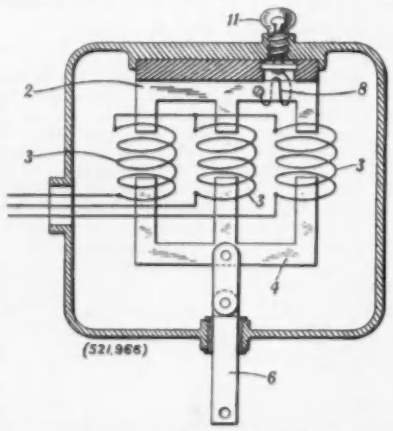
522,480. Agricultural Tractor. George Stephenson and Sons, Limited, of Newark-on-Trent, and G. Stephenson, of Newark-on-Trent. (3 *Figs.*) November 15, 1938.—The invention is a fitting for agricultural tractors which overcomes the difficulties resulting from compacting of the soil on and by the driving wheels. An angle iron bar 11 extends across the tractor behind the driving wheels, and is combined with the usual draw-bar arrangement 12. Near each end, directly in line with the driving wheels, the bar carries a stout tine 13, shown in an inoperative position, each tine consisting of a curved



steel bar to the lower end of which is bolted a metal plate 15 pointed at the bottom. As the tractor moves forward, the tines pierce the ground and are dragged through it, so that the compacted soil in the track of each wheel is broken up. Each tine is clamped to a spindle mounted in lugs on the bar 11, both spindles being rotated in unison by a hand lever 21 working over a quadrant so that the tines can be raised and lowered at will. To prevent the accumulation of soil on the driving wheels, a scraper 28 is attached to each end of the bar 11 and projects between the two rows of spuds 27 on each driving wheel. These scrapers are adjustable to take up wear. (*Accepted June* 19, 1940.)

ELECTRICAL APPARATUS.

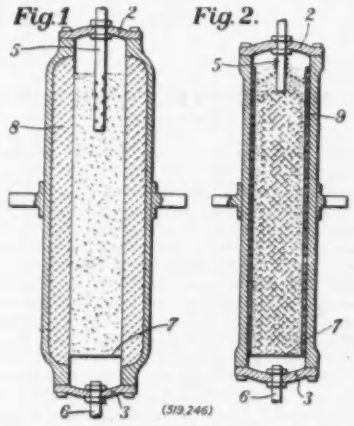
521,966. Electro-Magnet Indicator. E. R. Elliston, of London. (1 *Fig.*) November 29, 1938.—The invention is an automatic indicator which shows when the iron circuit of an electro-magnet, having an iron core



to which an iron armature is attracted, is completed. This information is important in alternating-current magnets in which the impedance rises rapidly as the length of the air gap approaches zero. The electro-magnet shown is used in an electro-mechanical brake, and has an E-shaped magnet core 2. The core is insulated from the casing, and each limb carries one phase 3 of a three-phase star-connected winding. An E-shaped armature 4 is connected by a link to an operating rod 6, which slides in a bushing in the casing. Adjacent to one coil 3 the core carries a low-voltage secondary winding 8, one end of which is connected to the core, while the other end is connected to one side of a low-voltage indicator lamp 11. The other side of the lamp is connected to the casing and through the latter to the armature 4. The circuit of the lamp can thus only be completed by contact of the armature with the core. The arrangement is entirely self-contained and although the armature pole pieces work within the coils, and the several pole faces are not normally visible, the lamp always shows whether the armature gets home. (*Accepted June* 5, 1940.)

MISCELLANEOUS.

519,246. Carbonisation Process and Retort. The Institution of Gas Engineers, of London, and F. J. Dent, of London. (2 *Figs.*) October 7, 1938.—The invention is based on the reaction between coals and hydrogen, under pressures above about 5 atmospheres, which, when once initiated by heating, proceeds rapidly with evolution of heat. When a temperature above about 800 deg. C. has been reached, the reaction slackens and if no further heat is supplied the temperature falls and the reaction ceases. At this stage, the coal has become more or less carbonised. The apparatus consists of a cylindrical high-pressure metal retort closed at its ends by pressure-tight doors 2 and 3, which can be removed for charging and discharging. In order to facilitate these operations, the retort is mounted on trunnions. The hydrogen is introduced through an inlet pipe 5 and the gaseous and volatile products are withdrawn through an outlet pipe 6. A grate 7 supports the charge. The apparatus shown in Fig. 1 has a lining 8 of refractory material and is suitable for the treatment of coals which do not form plastic layers impervious to gas during the hydrogenation. Materials, such as caking coals, which form plastic layers impervious to gas are treated in the apparatus shown in Fig. 2. The retort has a metallic lining 9 cooled by the flow of water through a helical groove cut between the lining and the wall of the retort. Water-cooling pipes are also arranged at the upper part of the



retort around the inlet pipe and between this pipe and the lining. The charge of coal to be treated is subdivided and screened to remove fine grades below ¼ in., and, in charging, these finer grades are arranged around the inner wall, the bulk of the charge consisting of the larger grade. Some of the finer grade is also arranged around the inlet pipe. Owing to this distribution of grades and to the effect of the water-cooling, impervious plastic zones are formed adjacent to the lining 9 and at the upper part of the charge during the treatment, thus preventing "channelling" of the gas along the wall of the lining. The plastic zones formed in the larger-grade coal constituting the bulk of the charge are less impervious and the charge remains "open" to the flow of the gas. The length of the retort is from 10 ft. to 20 ft., and the internal diameter of the lining varies between about 2 ft. and 8 ft. The process is carried out as follows:—A current of hydrogen under a pressure of 50 atmospheres is passed through the charge at a rate of 2,000 cub. ft. to 2,500 cub. ft. at N.T.P. per hour per square foot of internal cross-section of the retort. At the commencement of the process, the gas is pre-heated electrically to about 800 deg. C. When reaction has commenced, say, after about 10 minutes, the pre-heating is reduced to about 500 deg. C., and this temperature is maintained until reaction has ceased. Fusion of the coal during the process does not hinder satisfactory carbonisation, so that it is unnecessary to provide for agitation of the coal. The coke produced by the process is generally of high reactivity and has a finely porous structure and a low sulphur content. The gas produced in the process has a high calorific value. (*Accepted March* 20, 1940.)